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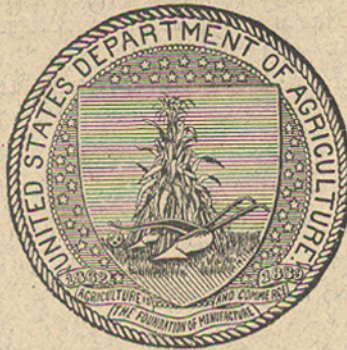
U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS—MILTON WHITNEY, Chief.

SOIL SURVEY OF BLUE EARTH COUNTY, MINNESOTA.

BY

HUGH H. BENNETT AND LEWIS A. HURST.

[Advance Sheets—Field Operations of the Bureau of Soils, 1906.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the Congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS,

Washington, D. C., November 13, 1906.

SIR: In compliance with requests transmitted to the Bureau by the Hon. J. T. McCleary, a soil survey of Blue Earth County, Minn., was made during the summer of 1906. I transmit herewith a report on this work and recommend that it be published as advance sheets of the Field Operations of the Bureau of Soils for 1906, as provided by law.

Respectfully,

MILTON WHITNEY,

Chief of Bureau.

HON. JAMES WILSON,

Secretary of Agriculture.

CONTENTS.

	Page.
SOIL SURVEY OF BLUE EARTH COUNTY, MINNESOTA. By HUGH H. BENNETT and LEWIS A. HURST.....	5
Description of the area.....	5
Climate.....	9
Agriculture.....	11
Soils.....	20
Marshall silt loam.....	23
Fargo clay loam.....	27
Marshall clay loam.....	29
Fargo clay.....	32
Marshall fine sand.....	35
Marshall fine sandy loam.....	37
Marshall loam.....	38
Fargo fine sandy loam.....	40
Wabash silt loam.....	41
Wabash fine sandy loam.....	43
Mankato sand.....	44
Mankato sandy loam.....	45
Judson loam.....	46
Mankato loam.....	47
Meadow.....	48
Peat.....	49
Summary.....	51

ILLUSTRATIONS.

FIGURE.

	Page.
FIG. 1.—Sketch map showing location of the Blue Earth County area, Minne- sota.....	5

MAP.

Soil map, Blue Earth County sheet, Minnesota.

SOIL SURVEY OF BLUE EARTH COUNTY, MINNESOTA.

By HUGH H. BENNETT and LEWIS A. HURST.

DESCRIPTION OF THE AREA.

Blue Earth, one of the second tier of counties from the northern line of Iowa, is situated in the central part of southern Minnesota and is included approximately within the meridians $93^{\circ} 45'$ and $94^{\circ} 30'$ west longitude and parallels $43^{\circ} 50'$ and $44^{\circ} 15'$ north latitude. Its northern boundary is indented by the great right-angle

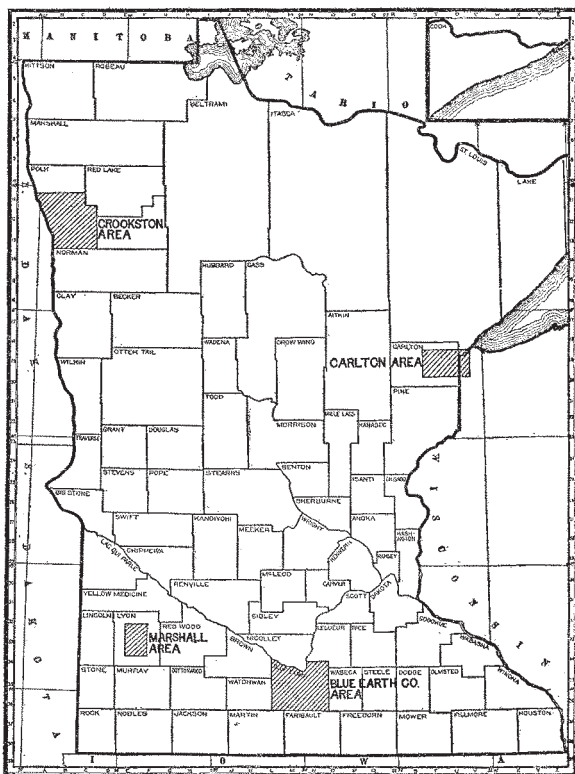


FIG. 1.—Sketch map showing location of the Blue Earth County area, Minnesota.

bend of the Minnesota River, which marks the southernmost point of that stream. Mankato, located at the vertex of this angle, is about 150 miles west of Winona on the Mississippi River and nearly 90 miles southwest from Minneapolis and St. Paul. Blue Earth County is bounded on the north by Nicollet and Lesueur, on the

east by Lesueur and Waseca, on the south by Faribault and Martin, and on the west by Watonwan and Brown counties. Its length from east to west is 30 miles, and its breadth from north to south varies from $21\frac{1}{2}$ miles in the middle to 29 miles along the western boundary. The land area of the county is approximately 749 square miles, or 479,104 acres. About 22,000 acres more are included in water systems. A very large proportion of the area is under cultivation, while practically all the remainder is utilized as mowing and pasture lands.

While in its surface features the county varies from flat to hilly, by far the larger part is flat to gently rolling. The northeastern part, included in the townships of Jamestown, Le Ray, and northern McPherson, is quite broken and hilly and embraces a number of comparatively deep lakes. The section between Eagle Lake and the Minnesota Valley bluff east of Mankato, narrowing around to the south of the city, is quite flat. All the area north of Lesueur River was formerly heavily timbered with elm, maple, ash, oak, etc., and constituted a part of the "Big Woods," which extended northward 100 or more miles. Most of the timber has been removed and the land brought into cultivation.

That part of the county north of the Watonwan and west of the Blue Earth River is in the main gently rolling, with the highest elevations generally not more than 20 to 30 feet above the lowest. There are a number of low-lying, flat areas—the beds of old lakes—particularly in the townships of Cambria, Butternut Valley, Judson, and Lincoln. In Lincoln Township there are many small knolls and mounds of sand, standing from 5 to 15 feet above the surrounding level country.

The central and southern sections of the county, lying south of the Le Sueur and the Watonwan rivers, embracing nearly three-fourths of the total area, is flat, undulating, or only gently rolling, becoming more nearly level as the southern boundary is approached. The townships of Vernon Center, Pleasant Mound, Sterling, Lyra, Mapleton, and Danville are generally quite flat, with the exception of the broken country in the neighborhood of streams and the group of small hills in other vicinities of Pleasant Mound and Sterling Center. These hills, rising from 30 to 75 feet above the surrounding country, are rather elongated or ridgelike, though not noticeably parallel.

In the vicinity of Mapleton, mainly to the south and southeast of the town, there is a large area so flat that one can look out across the country for miles without noticing the slightest inequality in the surface configuration.

In general, the area is a flat to gently rolling expanse with an imperceptible slope from the east, south, and west toward the central northern part of the county, which gives direction to stream

courses. The entire county lies within the drainage basin of the Minnesota River, a tributary of the Mississippi. Almost the whole area is drained by the Blue Earth River with its tributaries, the Watonwan, and the Le Sueur with its tributaries, the Maple, and the Big and Little Cobb rivers, which converge within a radius of 10 miles from the point of confluence of the Blue Earth with the Minnesota River. The average altitude of the upland is nearly 1,000 feet above sea level.

In detail, the Blue Earth and the Watonwan rivers drain the southwestern part of the county, the Maple the south-central part, the Big and Little Cobb the southeastern, and the Le Sueur the northeastern part. There are several lesser streams that flow directly into the Minnesota. One of these, Minneopa Creek, drains a considerable proportion of Butternut Valley, Judson, Lincoln, and Gordon City townships. These streams have cut deep, troughlike channels, which increase in depth below the general upland level from about 20 feet near the county line to 200 feet at the coalescence of the Blue Earth and Minnesota valleys. There are many rapids, but few falls, in the streams. The bluffs usually rise steeply from narrow bottoms or directly above the stream on the convex sides of bends, while the general upland is reached on the concave sides by a more gradual ascent, frequently by a series of steplike benches or terraces. Often the bottom land stretches away for one-half mile or more from the river in a kind of semicircular excavation, usually with a slope outward, marking those places deserted by the river with a change of its channel. The Minnesota Valley is from 200 to 225 feet deep. The valley proper varies from very narrow on the Blue Earth side, in places west of Mankato, to a little over 2 miles in Lime Township. The valley is interrupted by terraces of various altitudes and ranging from 20 to 150 feet above the stream. There are many rock exposures in the valley. Good constant flows have been secured from artesian wells at several points in the stream valleys.

The country in the neighborhood of streams, where erosion has been most active, is always more or less broken and rolling. Some of this is too rough for profitable cultivation. The land surface is interrupted here and there by glacial lakes varying in size from those too small to represent on the map to bodies 2 square miles in extent. The principal lakes in point of size are Jackson, Madison, Eagle, and Loon. About five-sixths of the area was originally prairie. The streams and lakes were fringed with a narrow strip of timber.

Indian Lake, about 3 miles southwest of Mankato, occupies part of an old valley cut by the Le Sueur River, which was forsaken when the plateau separating this from the Blue Earth River was cut

through. This valley lies from 75 to 100 feet below the general upland level; in its highest point is about 50 feet above the present level of the Le Sueur, and is about 3 miles long.

The isolated plateau between this valley and that of the Blue Earth has been badly cut by erosion. There is an interesting plateau about 70 feet above the surrounding level in Sibley Park in west Mankato Township in the angle formed by the confluence of the two rivers.

Blue Earth County, originally included with Dakota County, was organized in 1853, but the boundaries have been changed several times since its organization. The first settlement was made at Mankato in 1852, following which the surrounding country was explored and gradually settled. Much of the country was settled by so-called companies or colonies, a form of colonization in vogue about this time. These companies were not corporate bodies, but were groups of individuals associated together for the purpose of rendering mutual assistance and protection and for making claims to town sites. Mapleton was settled by the Minnesota Settlement Association, which formed in New York in the winter of 1854-55 with a membership of about 200. A location was selected by an advance agent, the colony arriving in 1856. A large Welsh colony came from Ohio the same year.

While most of the early settlers came from the older eastern settlements, a great many of the present landowners came direct from Europe. The population of the county in 1899 was about 32,000. This was made up of Americans, Germans, Swedes, Norwegians, and Welsh, named in order of relative numbers. There are many Welsh in the Lake Crystal neighborhood, while the section southwest of Vernon Center is largely settled by Germans. The population is quite cosmopolitan throughout the county, it being not uncommon to hear several languages spoken in almost any small community.

As a rule the farmers are a sturdy, hard-working, broad-minded class, who on account of differences in nationality have not been drawn off into close communities with set ideas and practices, but are quick to learn and use the practices of other sections which have proved successful. Prosperity is nearly universal. Many of the farmers have acquired considerable wealth and now live in the towns and rent their farms. Generally the farmers' houses are neat and substantial, while the barns, granaries, and other buildings are commodious and comfortable.

Not infrequently a small log house, the settler's earlier dwelling, stands near a handsome residence in such striking contrast as to afford a vivid illustration of the great progress made in a comparatively short period. Most of the heavy labor around farmhouses, such as pumping water, grinding or shredding feed, and storing hay

in barns is done by windmills, gasoline engines, or horsepower. Always the farmhouses are protected from the cold north and western winds by wind-breaks of cottonwood, willow, or other trees. Owing to the scarcity of timber growth a large part of the farm fuel consists of coal, hauled during the summer when the roads are good. Telephones, rural free delivery of mail, and cooperative creameries have gone far to lessen the isolation and drudgery of farm life. Churches and good comfortable schools are everywhere convenient. The roads are excellent in summer and fall, but are apt to become badly cut up or even impassable in many low places during the spring thaws.

Mankato, the county seat, with a population of about 12,000, is an important railroad and manufacturing center. The other important towns are Lake Crystal, Vernon Center, Garden City, Amboy, Mapleton, Good Thunder, Madison Lake, and Eagle Lake, with populations ranging from 300 to 1,200. The transportation and market facilities are excellent. Only a small proportion of the county is situated more than 10 miles from a shipping point. A considerable part of McPherson and Medo townships is rather inconvenient to markets, but even here the most outlying point is less than 15 miles from a station, and with the completion of the road through St. Clair, which is now in course of construction, this distance will be considerably lessened. The Chicago Great Western, the Chicago, St. Paul, Minneapolis, and Omaha, the Chicago, Milwaukee, and St. Paul, and the Chicago and Northwestern lines enter the county. There are grain elevators and cattle yards at convenient points along these lines throughout the county, and flour mills at various towns with outputs of 50 to 1,000 barrels a day. Thus, with moderate freight rates, secured through keen railroad competition, and with rapid service to Omaha, Minneapolis, St. Paul, Chicago, and other large cities, there should be no trouble in finding outlets for any kind of produce.

CLIMATE.

The appended tables giving the records of the Weather Bureau station at New Ulm, just outside the area to the northwest, show the annual precipitation of 26 inches. About 80 per cent of this rainfall occurs in the warmer months, from April to October, inclusive, when it is most needed. The unusually high organic matter content and rarity of prolonged spells of hot weather are factors conducive to the maintenance of a favorable soil-moisture supply, so that the normal rainfall is sufficient for all needs. The problem of drainage and removal of surplus water from low, flat places gives rise to more concern than does insufficient rainfall. However, there do occur occasional wide fluctuations from the normal rainfall. The last five growing seasons have been unusually wet, especially in the

early part of the season, and a considerable area of land formerly cultivated in grain or corn has dried out too late to be used for any other purposes than pasturage, hay, or for such late crops as millet, buckwheat, and flax. Droughts in late summer and early fall sometimes give rise to a hardened or baked condition of the soil, which interferes with fall plowing.

The winters are long and severe, but the cold is rendered less noticeable by the low humidity. January and February, with mean temperatures of about 13° and 15° F., respectively, are the coldest months, while July, with a normal of about 74° F., is the warmest. There are occasional spells of brief duration when the temperature drops down toward 37° below zero, while, on the other hand, summer heat very rarely registers 100° F., although an extreme maximum of 104° F. has been reached. Thus the extreme range of temperature is very nearly 139° F. The summer nights are almost always cool and pleasant, especially on the uplands.

During the last eight years the average dates for last and first killing frosts were May 10 and 12 and September 22 and 24, respectively, for New Ulm and Pleasant Mound, while the dates of the earliest and latest killing frosts were September 8 and June 7. Late-planted corn is damaged sometimes by early frosts.

The ground usually freezes to a depth of about 3½ feet. When this depth is once reached the lower portion rarely thaws out until the general spring thaws. Little damage is done by heaving during these severe freezes. The alternate freezing and thawing of the surface soil in mild winters and early spring does most damage to crops. Clover is particularly apt to suffer from such changes. Sudden freezes following saturating winter or early spring rains do considerable injury to clover. Rye, the only fall-seeded grain, sometimes suffers considerably on poorly drained soils, yet some of the best rye yields of the country are made in Blue Earth County. Winter wheat has been grown in southeastern Minnesota and experimentally in the Minnesota River Valley, producing considerably better yields than the spring varieties. It is likely that hardy varieties will be secured and eventually the winter-wheat belt will be extended north of Blue Earth County. It is claimed that corn grown here from year to year makes a gain in hardiness to suit the environment. Apples seem to adapt themselves to the climate, particular varieties doing better as time goes by. More hardy winter varieties are badly needed.

During winter the prevailing winds are from the north and northwest and generally from the south and southwest throughout the growing season. Strong winds blow almost incessantly in the spring and early summer. The most disastrous results come from the occasional hot, dry winds from the south about the time grain is

maturing. If these come when the grain is still in the milk its full plump development is prevented. A moderately cool and dry condition of the air, with only light rains and cool breezes after flowering, is best suited to development of plump, bright No. 1 wheat.

Well water is always cold even where the water level is only a few feet below the surface. The subsoil is generally cool even after prolonged hot spells. On account of this low soil temperature and the shortness of the season oxidation of vegetable matter in the soil is slow. This goes far to account for the high organic matter content and consequent black color of the soils of the county, which prior to the advent of agriculture were long covered with a luxuriant growth of prairie grasses.

Normal monthly and annual temperature and precipitation.

Month.	New Ulm.		Pleasant Mound. ^a		Month.	New Ulm.		Pleasant Mound. ^a	
	Tem- perature.	Precipi- tation.	Tem- perature.	Precipi- tation.		Tem- perature.	Precipi- tation.	Tem- perature.	Precipi- tation.
	° F.	Inches.	° F.	Inches.		° F.	Inches.	° F.	Inches.
January...	12.6	0.80	15.8	0.38	August....	71.4	3.33	65.0	1.90
February..	14.9	.94	15.0	.57	September..	61.4	3.09	60.8	3.85
March.....	26.3	1.74	29.0	1.53	October....	48.5	2.17	49.8	2.38
April.....	45.9	1.89	42.5	2.48	November..	31.2	1.03	32.2	1.02
May.....	60.5	2.99	58.8	3.38	December..	17.5	.68	19.5	.60
June.....	69.3	4.14	65.3	4.89	Year.....	44.5	26.32		
July.....	74.4	3.52	70.6	3.58					

^a For Pleasant Mound the figures under temperature for August and September represent the temperature for those months in the year 1904, and under precipitation the figures for April and August represent the precipitation for those months in the year 1904.

Dates of first and last killing frosts.

Year.	New Ulm.		Pleasant Mound.		Year.	New Ulm.		Pleasant Mound.	
	Last in spring.	First in fall.	Last in spring.	First in fall.		Last in spring.	First in fall.	Last in spring.	First in fall.
1897.....	June 7	Sept. 16	May 31	Oct. 9	1902.....	Apr. 24	Sept. 11	Apr. 24	Sept. 12
1898.....	Apr. 25	Sept. 8	May 13	Sept. 11	1903.....	May 1	Oct. 9	May 3	Sept. 28
1899.....	May 13	Sept. 29	May 13	Sept. 29	1904.....	Apr. 26	Oct. 6	Apr. 27	Oct. 6
1900.....	May 4	Sept. 17	May 4	Sept. 17	Av.....	May 10	Sept. 22	May 12	Sept. 24
1901.....	June 7	Sept. 20	June 7	Sept. 19					

AGRICULTURE.

While the first settlement in Blue Earth County was made in 1852, but little real farming was done until after 1859. In 1853 the Sioux Indians were removed above New Ulm, as provided in the treaty of 1851. Following this, explorations made into the surrounding uplands led to the opening of farms along the Minnesota River, the Blue Earth and its tributaries, and on the prairies in the neighborhood of the various town sites. Land was acquired by preemption at \$1.25 an acre up to the time of the passage of the homestead law

in the early sixties, after which it was taken up by squatter's or by soldier's rights, without the requirements of actual occupation. In the case of the Winnebago Reservation, after the removal of the Indians, the Government sold the land by sealed bids.

At first the agricultural possibilities of the soil were unknown. Although most of the county was open prairie, the timbered land was taken up first for the reason that the prairies were very poorly drained. Because of numerous sloughs and lakes many sections either had no roads during summer or the roads were frequently impassable, except when frozen, making it necessary to haul wood and supplies long distances in cold weather. Gradually, with the increase in the area of cultivated land, the sloughs and shallow lakes dried up, the roads improved, and the prairies fell under cultivation.

The earlier settlers built log cabins and grew patches of corn, potatoes, and rye for home use. In 1859 the crops, named in order of importance, were corn, oats, wheat, barley, and rye. In that year 72,000 bushels of corn and about 21,000 bushels of wheat were produced. Wheat had to be cradled until along in the sixties, and this, coupled with the fact that the crop was grown largely for shipment and that transportation facilities were extremely poor, had more to do with the comparatively small wheat acreage than did ignorance of soil adaptation. Boats began to run more frequently after this year. In 1869 wheat and oats production had run far ahead of corn, the yields being approximately 725,000 bushels of wheat, 467,000 bushels of oats, and 198,000 bushels of corn. Usually the land was plowed in the fall for wheat and in the spring for corn. After the introduction of flax in the seventies it was the custom of some to plant newly broken prairie sod to flax.

There occurred from time to time various mishaps to retard agricultural developments. Upon the occupation by the Winnebago Indians in 1855 of a reservation including the townships of McPherson, Decoria, Rapidan, Lyra, Beauford, Medo, and parts of Le Ray, Mankato, and South Bend, about 234 square miles of land in the center of the county was thrown out of agricultural operation.

The effects of the panic of 1857 were felt in the county, but not until 1858 and 1859. Townsite land had been forced up to a fictitious valuation by a fever of speculation, or "townsite craze," which had built a number of "paper towns" throughout the county. The price of all commodities was high. Farmers were not able to market their products for the want of transportation facilities. Money became scarce and rates of interest high. Some of those who mortgaged to eastern money lenders at rates frequently as high as 24 per cent later lost their property, and a few disheartened settlers returned East.

Another serious setback to agriculture came with the Sioux massacre in 1862, by which practically the entire county west of Mankato was depopulated. With crops destroyed and farms abandoned, property decreased in value for a short period of panic, during which good farms were offered at ridiculously low prices. In 1863, after strong protests from the people, the Government moved the Winnebago Indians from the Blue Earth County reservation. From this time on agriculture advanced steadily, except for an interval of three years between 1874 and 1877, when the county suffered universally from the devastating effects of grasshoppers.

Until the advent of railroads all transportation of agricultural products was by steamboat. In 1866, 190,000 bushels of wheat were shipped from Mankato by boat. An extensive river traffic was built up, but this began to decline in 1867, when the Omaha Railroad reached Mankato, and practically ceased with the opening of the Northwestern line to New Ulm in 1871. The railroads gave a wonderful impetus to immigration and to agriculture. Before their advent wheat had to be stored, as the river was navigable on the average only for about two months in the spring. There was a great increase in the production of corn during the decade ending with 1879, in which year nearly 690,000 bushels were grown, against about 700,000 bushels of oats and 858,000 bushels of wheat. The live-stock industry began to assume considerable importance about this time. Creameries owned by nonresident companies were first operated in the eighties. These gave way to cooperative creameries about 1890, whereupon the dairy business was forwarded greatly. In 1899 the production of the leading cereals was 1,697,760 bushels of corn, 1,391,000 bushels of oats, and 2,177,000 bushels of wheat; yet with this comparatively large yield of corn and oats the county was, properly speaking, a wheat-growing county, since in this year 156,610 acres were cultivated to wheat, while 44,214 and 39,746 acres were in corn and oats, respectively. Yields of approximately 167,000 and 269,000 bushels, respectively, of flax and potatoes in 1889 were lowered to about 120,000 and 243,000 bushels, respectively, in 1899. While no crops once well established have been abandoned, certain varieties have appeared and disappeared. Fife wheat was the principal variety grown prior to about 1880, but since then bluestem has been grown almost entirely. Other varieties of wheat and oats have been exploited in the county for short periods.

Land had reached a valuation of from \$10 to \$15 an acre in 1880, and from \$20 to \$30 in 1890. In 1899 a sugar beet company was organized for the purpose of growing sugar beets as an experiment. The experiments were made on the lighter terrace and first bottom soils of the Minnesota River Valley north of Mankato. The average yield was about 9½ tons per acre, while the average percentage purity and

sugar content were, respectively, 83.8 and 14.06. Owing to the excessive rental of \$8.50 an acre and exorbitant charges by the contracting sugar factory for seed and tools furnished, losses from overflow, the cost of shipping, and heavy deductions at the factory, the experiment was a financial failure. The final conclusion of the experiments was that where a farmer cultivates only so much land as can be worked by his own family without any expense for other labor, he might in a favorable season make the business a profitable one. Some farmers have grown beets profitably, while others have had contrary experiences. Yields of over 11 tons per acre of good quality beets have been grown on the better drained Fargo clay loam east of Mankato. Experience has shown that a crop of beets preceding wheat is very beneficial to the wheat, increasing the yield considerably. This year (1906) several farmers were induced by agents of the Carver County Beet Sugar Company to put in several fields of beets. The farmers were furnished the seed and advised as to the character of the soil and the methods of cultivation suited to the crop. The company contracted for the beets at \$4.50 per ton.

The absence of a local sugar beet factory and the scarcity of labor rather discourage the present introduction of the crop. However, in view of the need of more diversification, the suitableness of the climate and the adaptation of the deep, better drained soils to beets, it would seem that the crop warrants attention at least in a small experimental way. Beets can be made to fit in with other crops so as to make an even distribution of labor, except in the harvesting and marketing season. The main work of thinning and weeding comes in June and July, when other farm work usually is not pressing.

At present the system of agriculture practiced throughout the county is general farming in connection with dairying and stock raising. Exclusive stock or dairy farms are almost unknown. Generally from 30 to 50 per cent of the cultivated area of farms is seeded to wheat, while hay, corn, oats, barley, rye, and flax are next in importance in the order named. The acreage of corn, oats, barley, rye, millet, and clover is being increased slowly while that of flax and wheat is falling off. The spring wheat of this section of Minnesota makes excellent flour. It appears that the grade of wheat is determined more by climatic conditions than by soil or soil manipulation—all grades, Nos. 1, 2, and 3, being grown on the same soil in different years. It is claimed that the barley, on account of its dark color, is better suited for feed than for malting purposes. Flax is profitable, but only one crop can be grown on the same field within a period ranging from six to ten years according to the type of soil, for the reason that the second crop wilts. This is probably the result of a disease—flax wilt—which develops in the stubble of the first crop.

Some good apples are grown on a small scale here and there. The Duchess, Wealthy, Northwestern Greening, and Wolf River are varieties most generally found. Good winter varieties are needed. Strawberries, raspberries, and blackberries of excellent quality are grown on a small scale for local markets and for shipping. Such vegetables as cabbage, onions, rhubarb, and horseradish are produced, but not in sufficient quantity to supply the local demands. Most of the corn and hay is consumed on the farm. The value of these crops, particularly of the wild and tame hay, has been enhanced greatly by the live-stock industry. Small patches of broad-leaf tobacco have been grown from time to time for home use.

The live stock and dairy industries are causing a change from grain farming to a more diversified system. Those farms, which include a large area of low-lying, poorly drained land suited only to wild grasses, have been particularly benefited. Before the advent of the stock industry large quantities of good wild hay went to waste, while tame grasses and clover received but little attention.

Hog raising is proving quite profitable. Present indications are that this industry will continue to increase and probably in the near future will be one of the most important lines on every up-to-date farm. Sheep raising is a paying industry, especially on those farms adapted to grasses or infested with quack grass.

While one frequently hears that one soil is more productive than another, very few of the soils of Blue Earth County are reputed as being especially adapted to any one crop. Generally the organic matter content of the soils is so high that in favorable years fairly good yields of the general farm crops can be secured even from the lightest types. Again, a very large proportion of the cultivable area embraces clays and heavy clay loams having such narrow textural differences that agricultural methods have been quite uniform and differences in crop adaptation have received but little attention. However, it is pretty generally understood that the heavier, better drained types are better suited to wheat than are the fine sands or fine sandy loams. Some recognize that rye does best on the Marshall loam and the lighter phases of the Marshall silt loam.

It is generally conceded that the Fargo clay loam, when well drained, is a most excellent corn soil, but that wheat and oats planted on this soil are inclined to go too much to straw. Most of those familiar with the Wabash fine sandy loam class it as a good oat, corn, potato, and onion soil. Small fruits are grown largely on the rolling well-drained soils near streams, a practice evidently in accordance with their proper adaptation. The Judson loam is recognized by a few to be well suited to apples and in the more nearly level areas to wheat and corn. Generally orchards have been set out without

much reference to soil adaptations, sometimes being located in wet, soggy depressions, and potatoes frequently are grown on areas as little suited to this crop.

Rotation is very effective on the soils of this section. While systematic crop rotation has been neglected sadly, the productivity of many fields has been maintained fairly well simply through an occasional change of crops. Occasional pasturing of land has been invaluable in maintaining good soil condition on many farms. The naturally highly productive soils have given such good yields from year to year that farmers have not until recently been brought to see the dangers of continuous cultivation to one crop.

Wild oats, quack grass, and mustard lately have become serious pests, yet these have served to emphasize the need of improved methods. This year great losses have been sustained by the abundance of wild oats, particularly in the northwestern part of the county, where much grain has been cut for hay or, in some extreme cases, burned because of the presence of as high as 50 per cent of this pest. In the northwestern part of the county quack grass has been the cause on a few farms of a practical cessation of farming operations, resulting in the land being used almost entirely for grazing.

The general plan of rotation advocated, but rarely practiced, is corn, wheat one to three years, oats or barley, grass, clover, or a mixture of the two, to be cut for hay and pastured from two to four years. Some say that oats or barley should follow corn. Grass land is usually pastured until the sod begins to run out. A few turn under green clover after the first cutting. Generally clover is cut twice a year for hay, or the first time for hay and the second time for seed, and later smothered or weakened by grazing so as to winterkill. It is generally conceded that clover benefits land, whether cut, grazed out, or turned under green.

In the effort to eradicate or control wild oats and quack grass various schemes of rather indiscriminate rotation have been used without the popular acceptance of any one plan. The recent series of wet years has had a tendency to develop intensive farming. Where wet springs have retarded spring preparation of corn land, many who formerly did not do so are now fall plowing for this crop. The persistence of weeds is forcing more frequent cultivation, while drainage is being resorted to in the flat land and depressions, much of which has been too wet for use except as pasture, hay, or such subsidiary crops as flax, millet, buckwheat, etc.

Fall plowing, the prevailing method of soil preparation, is admirably suited to soil and climate. The heavy soils are not only exposed to the disintegrating and fining influences of frost, but vegetable matter turned under is decomposed before the soil freezes, while a

fall growth of weeds is killed by frost, and, finally, the land is well prepared for early seeding. As soon as the wheat crop is harvested and stacked plowing begins, often as early as the middle of August. The breaking is done with walking moldboard or surrey disk plows drawn by from two to five horses and with gang moldboard plows drawn by five horses. The depth of plowing varies from 5 to 8 inches in a small section in the northeastern part of the county to from 2½ to 5 inches in the southern part of the county. Occasionally early shallow plowing is followed by a later and deeper cross plowing, generally with the aim of weakening the quack grass by exposure of the roots. Some of the lighter types are not fall plowed for the reason that the soil is easily blown away. Not infrequently corn is harvested too late to permit fall plowing. In such cases grain is drilled in either without preparation or after disking or dragging. On fall-plowed land grain is put in with drill or seeder either with or without previous disking or dragging, depending upon the season and the extent of weed growth. Drills are most generally used. It is said that better results are had from drilling on light and dry soils, where the seed must needs be put in deeper. Some little disking is done in the fall after breaking. There are a considerable number who prefer not to plow in the fall for corn. Corn is pretty generally planted in check rows. The methods of cultivation are fairly uniform. Frequent shallow cultivation in both directions is done with 2 and 3 shovel cultivators. Little or no hoeing is done. Rye is practically the only grain crop sowed in the fall. Grass and clover, seeded along with grain, make a good strong growth before winter. Rape sown with grain at the time of seeding or a few weeks later affords excellent late grazing for hogs, sheep, and steers.

Summer fallowing or summer plowing is generally considered very beneficial, but is not practiced extensively. It is said that grain planted on fallow land goes too much to stalk, on account of the weeds turned under. Hence corn always follows summer fallowing. This might be looked upon as a kind of practice of green manuring, but while it is quite effective in destroying weeds and increasing yields temporarily, it does not seem to have the lasting beneficial effects of the ordinary system of green manuring.

No commercial fertilizers are used. Some farmers haul out barnyard manure as it is made and carefully scatter it over land intended for corn or on grass sod. Generally the supply is insufficient to cover all the cultivated area of the farms oftener than once in four or five years. Very little manure is applied directly for wheat, it being considered likely to cause too heavy a growth of straw and subsequent lodging. Too frequently the supply of manure is carried from the

barn and dumped in the barnyard, where rains cause its rapid deterioration.

A large part of the farm operations is performed by the farmer and his family. Few immigrants stop in the county now, as they seek cheaper western and Canadian land. Labor is very scarce. The harvest-season wages of \$2 to \$3.50 a day attract a few itinerant laborers, who are often of only ordinary efficiency. During the thrashing season farmers frequently cooperate. The land is well adapted to the use of modern farm machinery, such as gang plows, riding cultivators, wide harrows, harvesters, corn binders, hay loaders, manure spreaders, etc., and these implements are in general use, making the labor problem less serious.

More intensive cultivation of a smaller acreage, coupled with an extension of live-stock industry, will make the problem still simpler. Small thrashing outfits owned by individuals or a few cooperating farmers would largely avoid the evils of the present troublesome system, under which thrashing of late harvested crops is sometimes delayed and weed seed is scattered far and wide.

About 70 per cent of the farms are operated by the owners and the remainder by share and cash tenants, with the former largely in the majority. The cash tenants pay a rental of from \$2 to \$3.50 an acre, while the share tenant gives the landlord one-half of the crops and one-half of the increase of the original stock. In recent years many farmers have moved into the towns and villages, leaving their farms in care of tenants. While some farms operated in this way have been well cared for, as a rule rented farms have not been properly managed. Cheap western and Canadian lands have attracted a large number of the most competent tenants.

There are no very large farms in the county, and "bonanza" farming has never been practiced. The average size of farms in 1899 was about 140 acres. Many own a section or more, but there are few farms in one body larger than a half section. With the present development of the stock-raising industry the farms are generally too large, but there is not likely to be any great decrease until the cheap lands of the North and West have been taken up and emigration in that direction slackened. Farmers are reluctant to decrease their cultivated acreage in favor of increased acreage for pasturage for the reason that pasturing is popularly considered an expensive way of using land. The price of land varies from \$45 to \$75, according to location and drainage conditions. Prices have been almost stationary during the last few years, or have even decreased in some instances, owing to the discouraging effects of wet seasons and weeds. Such a condition can be only temporary, and in reality probably will prove the means of hastening artificial drainage, with

a consequent increase of land values. The good results everywhere attending the construction of tile drains are already encouraging the extension of the system. Tiling is being done on a small scale throughout the county and quite extensively in the central, southern, and southwestern sections.

The soils of Blue Earth County are naturally very productive. They are as good as those of northern Illinois, where the same types are held at from \$125 to \$140 or more an acre. They equal in fertility and ease of cultivation any soils of the prairie States. While the yields have in some cases been lowered by continuous wheat cultivation, and while noxious weeds have made their appearance, the inherent productiveness of the soil has not been materially affected. Those lands spoken of as being "wheated out" are merely in a poor condition, which can be corrected or remedied in large measure by underdrainage, deep plowing, and more systematic rotation. The close similarity of the soils to those of northern Iowa, northern Illinois, and southern Wisconsin, where dairying and diversified farming have been the means of greatly increasing the land values, together with the fact that most of these black Marshall soils have been taken up, leads to the conclusion that this county is just entering upon its greatest era of prosperity and that its land values eventually must equal those of the sections named. These sections have become the leaders in the production of butter. The dairying and live-stock industries of Blue Earth County should gradually increase along with better drainage and more intensive farming. Inducements are offered for increased stock raising and dairying in the adaptation of a large proportion of the better drained soils to alfalfa and mangel-wurzels. It should be the plan of every farmer to keep enough live stock to consume practically all the corn, hay, oats, and forage crops produced on the farm and to preserve and carefully use all the resulting manure.

Some of the agricultural methods in use are exceptionally good. For instance, some farmers, by thorough preparation of corn land and subsequent frequent shallow cross-cultivation, keep the crop from the start well ahead of weeds and so conserve moisture that rain is not needed from the time the plant is a few inches high until it begins to tassel. The best results with corn are attained by fall plowing, spring disking, and dragging before planting to destroy weeds, followed by frequent shallow cultivation in checked rows. Shallow cultivation with drags begins before the corn is up and continues with a weeder or light cultivator until the stalks are well above the weeds. Weeders are not so efficient in wet years. When wild oats or quack grass appear corn should be hoed, so as to destroy every stalk of grass. In wet years unchecked corn is

seriously hurt by weeds. Continuous cultivation of wheat offers the most favorable environment for quack grass, wild oats, and mustard. In controlling these pests the growing of more corn and potatoes or other clean cultivated crop and less wheat is in the long run the most efficient method. Quack grass can be weakened by shallow plowing during spring and summer, cutting the plants just beneath the surface, followed by deep fall plowing to expose the roots. The pest can be smothered in various ways. Seeding to quick-grown thick crops, such as millet, and close grazing by sheep and hogs are effective and practical methods. For wild oats, cultivation to crops maturing ahead of the oats, such as rye, barley, and clover, to be followed by carefully cultivated corn, is the most effective plan.

Deeper fall plowing of all upland soils except the Marshall fine sand is advised for all crops, care being taken to increase the depth gradually. Objections are offered to deep plowing, because it is said that with dry winters deeply broken land is not apt to weather down into that fine, compact condition best suited to wheat. While this might be the case in very exceptional seasons, the objection might be overcome by heavy surface rolling, followed by light harrowing or mulching, to prevent excessive evaporation.

There are very few silos in the county. Silos are convenient for storing and preserving a wholesome, succulent feed, and more cattle can be kept on a given area of land by feeding ensilage than in any other way.

SOILS.

With a few unimportant exceptions the soils of the area are not related to the underlying rocks, but represent material brought into the area by a vast ice sheet which at one time covered the northern half of the continent. This sheet moved slowly across the country, carrying a load of clay, silt, sand, pebbles, and boulders, commingled by ice action. With the subsequent recession of the sheet northward a large area of Minnesota was left covered with an unstratified sheet of glacial till or drift more than 200 feet deep in places. Since deposition the mass has undergone some very important changes. The greatest change, and the one that concerns man most, is represented in the alteration of the surface 2 to 3 feet, or the cultivable portion, wherein the action of weather and plants, including the incorporation of the vegetable remains of the prairie grasses that flourished for many centuries following the recession of the glacial sheet, have changed the stiff, unyielding yellow till to mel-low, black loams or open clays. Where water collected in the

depressions to form shallow lakes fine material was washed in from the adjacent slopes which supported, at first near the edges, luxuriant growths of water-loving plants, accumulation of the remains of which resulted in the formation of peat and a gradual filling up of the lakes.

Underlying the dark-colored soil mantle is a mass of pale-yellow silty clay containing a few pebbles and rock fragments. This extends with but slight variation to the underlying rock, not infrequently at a depth of 200 feet. Often between 15 and 50 feet occurs a stratum of bluish material. The drift sheet tends to increase in compactness with depth on account of compression by the overlying mass. Occasionally strata and pockets of gravel and sand are encountered in wells and bluffs. A large boulder of granite, gneiss, or other crystalline rock is found here and there on the surface. Small rock fragments and pebbles are disseminated throughout the entire mass in small quantities, but seem to be far less conspicuous in the soil than in the underlying material. Knolls and ridges of gravel and sand mixed with clay and silt and considerable areas of sand occur at various places in the county, but most abundantly in the western and northwestern parts. They are indicative that a considerable area in the central and southern parts of the county may have been covered by water at one time.

The Jordan sandstone and the Shokopie and St. Lawrence limestones are exposed throughout the Minnesota Valley, but have little direct influence upon the character of the soils. The lower portions of the soil resting upon these formations are intermingled slightly with the degradation products of the rocks. The limestones are used in making cement and lime.

Sixteen distinct soils have been recognized and mapped in Blue Earth County. Classified according to topographic features these would fall into three clearly defined groups, namely, first bottom or overflow land, the terrace soils, and the upland soils. Classified according to origin they would be grouped into five divisions, as follows: Alluvial soils, or those deposited from running water; coluvial soils, or those brought down from higher land by water, snow, and frost action and accumulated along the lower gentler slopes or at the foot of bluffs; terrace soils, derived partly from stream deposition before the streams had cut their channels to the present depth and partly from weathering of the underlying rocks; glacial soils, representing the immense upland sheet of glacial till spread ages ago over the county by glacial action; and finally, cumulose soils, representing accumulations of the remains of water-loving plants in depressions like old lake beds.

The following table shows the soils of the area grouped according to origin:

Alluvial.....	{ Wabash silt loam. Wabash fine sandy loam.
Alluvio-residual...	{ Mankota sandy loam. Mankato loam. Mankato sand.
Colluvial.....	{ Judson loam.
Glacial.....	{ Marshall silt loam. Marshall clay loam. Marshall loam. Marshall fine sandy loam. Marshall fine sand.
Lacustrine.....	{ Fargo clay. Fargo clay loam. Fargo fine sandy loam.
Organic.....	{ Peat.
Unclassified.....	{ Meadow.

To assist in a more specific and clearer treatment the soils have been divided into classes—sands, sandy loams, loams, clay loams, and clays—according to their texture, or content of sand, clay, and silt, as determined by mechanical separation of the constituents of representative samples, and these classes have been separated into types and grouped into series distinguished by a number of similar features. A series includes those soils closely related in their origin and manner of formation, topographic features, color, structure, and other characteristics.

The Mankato series is quite limited in extent.

The Marshall series, largely predominating in the upland, includes the two main types of the area—Marshall clay loam and Marshall silt loam—and three lighter, less extensive members. The soils of this series have been derived directly from the glacial till and are characterized by their high organic matter content, dark color, and uniformity of composition. These dark-colored glacial soils of the Marshall series are the predominating soils throughout the central western and central northern States.

The other upland soils, the Fargo clay loam, Fargo clay, and Fargo fine sandy loam, differ in structure, organic matter content, topography and drainage conditions, as will be described later in detail.

Peat marks the extreme limit in organic matter content, being almost pure vegetable matter. Meadow is an indefinite type representing a condition rather than any definite soil characteristic.

The soils are unusually productive and very desirable, with careful treatment responding quickly to rotation, drainage, etc. The absence of rock obstructions and the generally nearly flat topography of the county combine to make labor-saving machinery well adapted to use in the county.

The names of the different soil types, together with their actual and relative extent, are given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marshall clay loam.....	185,152	38.7	Marshall loam.....	8,768	1.8
Marshall silt loam.....	128,704	26.9	Fargo fine sandy loam.....	7,680	1.6
Fargo clay.....	27,968	5.8	Peat.....	7,680	1.6
Fargo clay loam.....	23,936	5.0	Mankato sand.....	4,032	.9
Meadow.....	19,264	4.0	Judson loam.....	3,968	.8
Marshall fine sand.....	15,872	3.3	Mankato sandy loam.....	2,816	.6
Wabash fine sandy loam.....	14,828	3.0	Mankato loam.....	1,600	.3
Marshall fine sandy loam.....	13,824	2.9	Total.....	479,104	
Wabash silt loam.....	13,312	2.8			

MARSHALL SILT LOAM.

The Marshall silt loam, to a depth of 18 inches, consists of a dark-brown to black, mellow and friable silt loam of high organic matter content. The proportion of silt, especially in the upper 8 inches, is high and the soil, even when wet, is friable and free from stickiness. The dry soil, however, lacks the powdery, floury consistency characteristic of many silt loams with a small percentage of organic matter. The subsoil consists of a pale-yellow or yellow clay loam or silty clay, generally distinctly brittle in the upper part of the profile and stiff or slightly clammy in the lower part. Occasionally in the higher positions the subsoil is a bright yellow silt loam. Very rarely a large bowlder, usually of granite or gneiss, is encountered on the surface, and a few rock fragments and pebbles are disseminated through the soil mass, but the type as a whole is conspicuously free from rocks of all descriptions. The subsoil rests upon a very thick sheet of pale-yellow or yellow silt clay carrying a small quantity of rock fragments and pebbles. In places there occurs, at a depth of from 15 to 30 feet, a stratum of bluish stiff and plastic clay. The underlying or substratum material becomes very sticky and plastic when wet, frequently giving rise, after spring thaws, to bad conditions in the road beds. Upon drying it tends to shrink and break into small aggregates that impart a granular structure to the mass.

Considered as a whole this soil is remarkably uniform both in structure and texture, yet it grades into the Marshall clay loam so gradually that generally the boundaries between the two had to be drawn rather arbitrarily, particularly in the townships of Le Ray and Jamestown. In the more rolling areas where drainage has been good and surface erosion most active the soil is shallow and of a much lighter color. A few small knolls and ridges of a gravelly or sandy material occur, but these are not of sufficient extent to be shown on the map.

On account of the unusually high organic matter content, cultivation is quite easy over a broad range of moisture conditions. As soon as the ground becomes sufficiently firm in the spring to support horses, plowing can be done with but little danger of forming unwieldy clods, provided, in case of subsequent dry, sunny weather, the land is harrowed within a few days. The soil is not inclined to bake in dry weather, yet a heavy rain on a freshly plowed field, followed by dry weather, may cause the formation of a crust. This should be broken as soon as possible so as to destroy the capillary connection between the surface and lower soil—a condition favorable to the loss of moisture by evaporation.

The Marshall silt loam is the predominating type over a larger part of the northern half of the county. It follows the western county line almost uninterruptedly to near the northwestern corner of Pleasant Mound Township. From this point the southern boundary of this general area extends in an irregular line northeasterly to Good Thunder and thence along the west bank of the Maple River to near its confluence with the Le Sueur. From this point, broken and interruptedly, it dips southeasterly to the southeastern corner of Decoria Township, where it turns north to the Le Sueur River and extends to the county line along the northern bank of that river. North of the Le Sueur it is closely associated with the Marshall clay loam, occurring in about the same extent. Irregular bodies extend out into the Marshall clay loam along the entire southern boundary. An area approximately 5 miles long and 1 mile in average width extends southward from Good Thunder to the northeastern corner of Sterling Township. There are several isolated areas of a rather heavy phase occurring within the boundaries of the Marshall clay-loam belt. The type is interrupted throughout by areas of Fargo clay loam and Meadow.

This is the most generally rolling type of the area. Its topography varies from that of the gently rolling interstream prairie land to the quite rolling and broken country in the vicinity of streams, where erosion has been most active, and becoming most broken in the hilly region of Jamestown and Le Ray townships. There are no sudden breaks or abrupt changes in the surface configuration, but a gradual transition from the prairies to the eroded phase near streams on the one hand or a gentle blending with the hill country on the other hand. The general level of the upland is from 200 to 225 feet above the Minnesota River and about 1,000 feet above sea level. The type is drained by the Blue Earth River, with its tributary, the Watonwan River, and the Le Sueur River, with its tributaries, Maple and Cobb rivers. The valleys of these range from about 30 to 200 feet deep. From these main waterways small streams, draws, and frequently sloughs, reach out into the interstream country. There are several

creeks flowing through the type into the Minnesota River, the more important being the Minneopa, Morgan, and Little Cottonwood. There are extensive areas unbroken by any stream courses whatever. While as a rule most of the areas of this soil are well drained, much of the less rolling land needs tiling. With careful surface cultivation it maintains a favorable moisture supply, even in times of drought. It is the earliest of the extensive upland soils.

The Marshall silt loam has been derived directly from the unstratified glacial till, which closely resembles the loess of other parts of the Mississippi Valley. The black surface soil has been formed by alteration of the upper portion of the till through the agencies of weathering and vegetation. In the main, this alteration represents the incorporation of organic matter, the remains of prairie grass and other forms of vegetation that covered this region for many centuries.

The native vegetation in the larger or prairie portion consisted of prairie grass, slough grass, and flowers, with a fringe of timber along streams and lakes, mostly oak, aspen, cottonwood, elm, walnut, butternut, maple, ash, and hazel brush. The country lying east of the Minnesota River bluff and north of the Le Sueur River constituted a part of the "Big Woods" and supported a heavy growth of maple, elm, ash, and other trees. There exists an impression that the soil of the timbered land is inherently more productive than that of the prairie land. Probably such an impression has arisen from the better average results secured on the timbered land because of better natural drainage.

The Marshall silt loam, on account of its good natural drainage and power to conserve moisture throughout droughts, is suited to a wider range of products and is probably surer to produce an average crop than any other soil of the area. While the type is well adapted to corn, wheat, oats, barley, rye, flax, and grass, wheat, corn, oats, and hay make up the larger part of the crops produced on it. Corn yields from 35 to 60 bushels per acre, probably averaging 45 bushels; wheat from 12 to 26 bushels; oats, 40 bushels or more, and rye 40 or more bushels, according to drainage conditions. Flax yields from 8 to 20 bushels, averaging about 12 bushels; but only one good crop can be grown on the same land in a period of about eight years. Yields of from 1 to 2½ tons per acre of timothy or clover and timothy hay are secured at a cutting for a period of from two to four years, when the sod begins to run out. The soil is well suited to clover, seeded alone or with timothy, and in view of the beneficial effect of this legume a great deal more should be grown. Buckwheat, millet, and sorghum are grown, but on a small scale, and generally as last-resort crops for the late, low, wet places. Small garden patches of vegetables were seen on the better drained areas. The deep, loamy, well-drained phases will produce sugar beets, though none except patches of an

experimental nature have been grown. Under the present economic conditions—the absence of a sugar factory and the scarcity of labor—the crop is not likely to be attempted on an extensive scale. In the more rolling, better drained locations, especially near streams, excellent small fruits, such as blackberries, raspberries, strawberries, currants, and gooseberries, are being grown profitably on a small scale. Such places are also particularly well suited to plums and apples—fruits that have been neglected, particularly in securing hardy varieties having good keeping qualities. There are many young apple trees on the type, but too frequently they have been set out on poorly drained flat places or in depressions and left to care for themselves. It would prove of great advantage to farmers to select for orchards, as far as possible, the well-drained, deep, slope phases. Potatoes not infrequently are grown on flat, water-logged land, with better drained slopes, capable of growing a much better quality of potatoes, near at hand. A few experiments have shown that the drained areas are well adapted to alfalfa. The crop was given up in one instance, after two seasons of good results, on account of the serious damage done by alternate freezing and thawing during an exceptionally unfavorable winter. The crop would do well and would afford the means of raising more live stock, especially hogs. Some patches of tobacco are grown for home use in the neighborhood of Good Thunder. The leaf makes a heavy, rank growth and is rather strong and gummy. The abundance of troublesome weeds, especially in the northeastern and northwestern parts of the county, coupled with a marked decrease in grain yields here and there, necessitates the early adoption of a more systematic rotation of crops and improved agricultural methods generally. There are many good farmers on this soil who are managing their farms profitably and judiciously, but for improving fields now out of condition and maintaining the productivity of others it is advised that less wheat and more corn and clover be grown in the rotation. A more liberal use of stable manure will also help to keep this soil in good condition.^a At present manure is applied generally on the surface before corn. Once every four or five years is popularly considered often enough for the type of soil. There are many prosperous farmers on the Marshall silt loam, and its productiveness warrants universal prosperity. The type rents for \$2.50 to \$4 an acre and sells for \$50 to \$75 an acre. The prices are generally highest in the northeastern part of the county.

^a A test by the wire basket method, to determine the manurial requirements of this type, gave marked increases from the use of stable manure and from cowpea vines, the figures being greatly in excess of those obtained from any form of mineral fertilizer, although the increases due to the applications of a complete fertilizer with lime were very good.

The following table shows the average results of mechanical analyses of the fine earth of this soil:

Mechanical analyses of Marshall silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
15424, 15426, 15428.....	Soil.....	0.1	1.0	0.8	6.6	8.1	62.5	20.7
15425, 15427, 15429.....	Subsoil.....	.1	.6	.5	3.8	8.8	65.3	20.6

The following sample contains more than one-half of 1 per cent of calcium carbonate (CaCO_3): No. 15425, 16.3 per cent.

FARGO CLAY LOAM.

The soil of the Fargo clay loam is a very black and rather stiff clay loam, varying from 18 to 24 inches in depth and averaging about 22 inches. From 4 to 8 inches of the surface material is generally mucky in the deeper depressions. When wet, it resembles a clay, being quite plastic and sticky; when dry, it hardens, shrinks, and cracks. If plowed under favorable moisture conditions it can be put in a state of good tilth, as owing to its high organic matter content whatever clods are formed are easily pulverized. The subsoil is a pale or grayish-brown and sometimes bluish-black plastic clay loam or clay, carrying much silt. In wet seasons it is soft and mushy. Frequently the subsoil contains a small quantity of rock fragments and pebbles, and occasionally nodules of lime. In the townships of Cambria and Butternut Valley the content of fine sand is sufficient to make the type here noticeably lighter.

The Fargo clay loam is largely confined to the northern half of the county, where it occurs usually closely associated with the Marshall silt loam. It is most extensively developed in the large flat area just east of Mankato and in the townships of Cambria, Butternut Valley, and Judson. With the exception of the nearly flat areas bordering the Minnesota Valley bluff line east and south of Mankato, its topography is distinctly that of a flat depression. The type largely represents the beds of old lakes and shallow ponds, and much of it was under water when the country was first settled. Even now many of the sloughs and Meadow areas, if drained, would resemble very closely the Fargo clay loam. Many small areas of this type were included with other types because they were too small to be shown on the map. While a considerable proportion of the soil material consists of fine particles washed down from adjacent slopes—mainly from the Marshall silt loam—the type has been derived largely from the glacial till.

Owing to its topography, the Fargo clay loam is very poorly drained. When an outlet is provided, water circulates readily through the sub-

soil, as is evidenced by the immediate benefits derived from tiling. Small quantities of alkali are sometimes seen on the surface, where it has been deposited by evaporation. In very few instances was the quantity sufficient to injure crops. Under present drainage conditions maximum yields can be secured only in exceptionally dry years.

About the same crops are grown on this type as on the Marsnall silt loam. In wet seasons the soil is so late as to prevent the planting of the regular farm crops. During the last four or five years the soil has been so wet that a considerable area of the type that was formerly under cultivation has been thrown out or used for hay and pasture land. Flax, millet, or buckwheat, seeded late, as a last-resort crop, gives very good yields.

With adequate drainage this is the best corn soil of the area. Wheat and oats are apt to go too much to straw. Barley does very well. The soil is not particularly adapted to rye, potatoes, or vegetables.

It is the custom of the farmers to handle this soil according to the seasons, paying but little attention to artificial drainage. In dry seasons it is cultivated about as the Marshall silt loam, though it is the rule to grow more corn and less grain. No systematic crop rotation can be followed until better drainage is provided. Many of the lesser areas could be reclaimed by putting in only a few tile drains. The chances for earlier spring planting could be increased greatly by fall plowing. While the farmers recognize that the soil does not apparently need organic manures, occasional applications of barnyard manure are said to benefit it.^a

This is the type which has contributed most to the fame of the Red River Valley as a wheat-growing section. In the northwestern part of the county the value of land has been affected to a certain extent by the inadequate drainage conditions of the low, flat places, and in recent years the type here has depreciated slightly in value on account of the succession of wet seasons. Elsewhere the price of land generally is not affected by the presence of this type, although a great many farms include at least a small area of it. Artificial drainage would increase land values in some sections of the county where this soil occurs.

^a Laboratory culture tests of a sample of this soil indicate that the best manurial treatment is one that adds organic matter. The best plants were grown where the soil had been mixed with stable manure or green cowpea vines. In view of the fact that the soil is already well supplied with organic matter it seems surprising that better results should be obtained with the organic manures than with the mineral fertilizers, but such was the case in the experiments. The effect of the organic manures on the physical condition of the soil had doubtless a considerable influence upon the results.

The following table gives the average results of mechanical analyses of this type of soil:

Mechanical analyses of Fargo clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
15440, 15442.....	Soil.....	0.3	1.7	1.1	5.1	5.6	54.8	31.0
15441, 15443.....	Subsoil.....	.2	1.2	.8	3.6	5.6	49.9	38.1

The following samples contain more than one-half of 1 per cent of calcium carbonate (CaCO_3): No. 15440, 24.3 per cent; No. 15441, 21.0 per cent; No. 15442, 14.6 per cent; No. 15443, 12.8 per cent.

MARSHALL CLAY LOAM.

The soil of the Marshall clay loam varies in depth from 18 to 22 inches, with an average of 20 inches, and is a very black silty clay loam generally having a loose to mellow structure in the upper 6 inches, but becoming stiff and compact below. When moderately dry the soil is inclined to assume a slightly waxy nature. The organic-matter content is considerably higher than that of the Marshall silt loam. The subsoil varies from a clammy grayish-brown silty clay to a stiff, waxy yellow or brown clay. Sometimes the lower part of the subsoil is puttylike and is very sticky and adhesive. Texturally the soil is quite uniform, but with differences in topography and drainage its depth, color, and structure vary considerably. Ordinarily the better the drainage the deeper the soil and the lighter the color of the subsoil.

Where the soil has stood long without cultivation, particularly where plowed land has run together with soaking rains, baking and cracking are apt to take place in dry weather. On account of the high organic matter content cultivation is possible under a broader range of moisture conditions than with the general run of clay loams, yet in wet springs the soil not infrequently becomes so water soaked as seriously to retard cultivation. On the other hand, an unusually dry fall results in a hardened condition, making fall plowing very difficult. Generally clods formed by plowing the land too wet are easily broken down by the rains and by harrowing.

The Marshall clay loam is the most extensive type of the county, occupying 38.7 per cent of the land area, mainly in the southern and eastern parts of the county, as a broad, much interrupted belt running from the southeastern to the northeastern corner of the county. North of the Le Sueur River, in the original timbered district, there is an extensive occurrence of a lighter phase having a deeper and lighter-colored soil. This phase has the same hilly topography as the closely associated Marshall silt loam, making them so near alike

in superficial appearances that very careful examinations were necessary to establish boundaries. The topography of the main body varies from flat to gently rolling. In the neighborhood of Good Thunder and Vernon Center and through the townships of Pleasant Mounds, Shelby, Sterling, and Mapleton the type occurs in broad expanses of nearly flat to gently undulating country, interrupted only by the rolling country near streams and the small hills in the vicinity of Pleasant Mounds and Sterling Center. Along Blue Earth and Maple rivers it is quite rolling. The type east and north of Mapleton is mostly gently rolling.

The drainage conditions vary with the topography—the more rolling the better the drainage. While this soil generally can not be seeded so early as the Marshall silt loam, this year (1906), with a wet spring and an early summer, crops have usually been good even on much of the nearly level land. The exceptionally good drainage is probably due to the silty nature of the underlying clay. However, the type as a whole needs underdrainage. Considerable tiling is being done on this type in the southeastern part of the county.

The Marshall clay loam represents the glacial till modified by the growth and decay of vegetation. The remains of centuries of growth of prairie grass have given rise to a high organic matter content and a very black color to a depth of nearly 2 feet. This is an ideal wheat soil, and is also well suited to oats, barley, and corn. Rye does fairly well on the better drained phases, but poorly on the flat land. Where the drainage is good apples do exceptionally well for so heavy a type. Cabbage, onions, and beets thrive. Heavy yields of beets can be grown if the land is tiled. Potatoes are inclined to be a little soggy unless careful attention is given to drainage. Alfalfa would undoubtedly prove successful with better drainage, especially on the more rolling phase. Of the fruits, plums have given the best results.

So much depends upon the seasons in the case of this soil that yields can be estimated but roughly and under present drainage conditions these can hardly be looked upon as a true measure of the soil's productivity. Wheat yields from 13 to 28 bushels per acre, with an average of 17 bushels; corn from 35 to 60 bushels; oats from 35 to 50 bushels, and barley 40 or more bushels. The best results are obtained in a moderately dry year. This is a very durable soil, and high yields can be maintained with proper management. However, there are many farms where continuous cultivation to one crop and neglect of proper methods of cultivation have resulted in a condition of soil and an increase in troublesome weeds which combined have lowered the grain yields, especially those of wheat. It is the aim to break all grain land in the fall to a depth of from 2½ to 5 inches, but many adhere to the plan of breaking corn land in spring. Grain

is drilled in occasionally on corn stubble, where the corn can not be removed in time for fall plowing. Early fall plowing permits more thorough decomposition of the vegetable matter turned under, subjects a good growth of weeds to frost and, in case of a late spring, admits of earlier planting and cultivation. It is maintained by some farmers, especially in the southern part of the county, that this soil should not be plowed deeper than 4 or 5 inches, while others say 2½ to 4 inches is deep enough. It is perhaps true that more weed seed come up after shallow plowing, but it is evidently inadvisable to combat weeds in this manner if greater benefits can be derived from deeper plowing. The actual results show in general that deeper fall plowing is advisable. Care should be taken not to increase the depth of plowing more than an inch or so at any one time, since where more is turned to the surface than can be thoroughly weathered during the winter the yields are apt to be reduced. This effect is noticeable where ditches have been dug in the fields, weeds refusing to grow on the subsoil thrown out of the ditch. Again it is claimed that not infrequently the winter rainfall is inadequate to break down and compact deeply plowed land—a condition unfavorable to grain. The use of heavy rollers in the fall after breaking, or in the spring before seeding might prove a remedy in these exceptional cases. It would be necessary to follow the rolling with a light harrowing to prevent surface evaporation. That such packing would be of advantage in the cultivation of small grain is indicated by the better growth of plants where the heavy wheels of traction engines have firmed the soil. The grain on these spots grows much better, stands better, and has a brighter, stronger straw. Deeper plowing—from 4 to 8 inches—is practiced on the rolling phase of this soil in the northeastern part of the county, with good results.

Farmers are beginning to recognize that grain land should be cropped now or then to corn or some other clean culture crop, in order to maintain the fields in the best condition, especially as regards the subjection of weeds. Already the scheme of following corn with one to three years of wheat and then oats or barley is being practiced by a number of the more progressive. There are those who prefer to put a crop of oats after corn rather than wheat or barley, while others believe that oats are apt to go too much to straw. Clover and clover-grass mixtures should be grown more in rotation with the regular crops. It is the general rule to apply the bulk of the barnyard manure to corn. Wheat and oats seem to derive more benefit from the residual effects of manure applied to a preceding crop of corn, as they ordinarily go too much to straw and lodge if grown after heavy direct applications. Moderate applications once

in four or five years is deemed the best practice. There is generally not enough manure to cover the farm even in this way.^a

Grain does well after flax, but flax does not succeed after flax. Flax can not be grown on the same land oftener than once in eight or ten years, as otherwise it suffers from some disease, probably flax wilt. The type is well suited to dairying and stock raising, and these interests have an important place on it. The farmers as a rule are quite prosperous. Many have acquired a competence, rented their farms, and moved into town.

With adequate drainage this is probably the best soil in the area for the general farm crops. It is held at from \$45 to \$65 an acre in the southern part of the county, and a little higher in the northeastern part. Most of it rents for \$2.50 to \$3 an acre.

The following table gives the average results of mechanical analyses of the soil and subsoil of this type.

Mechanical analyses of Marshall clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
14951, 15434.....	Soil.....	0.3	0.7	0.9	4.9	4.2	53.0	35.8
14952, 15435.....	Subsoil.....	.1	1.3	1.6	10.1	6.3	48.4	32.7

FARGO CLAY.

The soil of the Fargo clay consists of a jet-black, generally waxy clay from 10 to 24 inches deep. As a rule, the soil is shallower in the occasional very slight depressions. The average depth is about 19 inches. The subsoil is a pale yellow, mottled yellow and gray, or light-gray very heavy and plastic clay, rubbing out between the fingers like soap. The subsoil always contains a high percentage of lime, largely in the form of concretions, to which the gray colors are chiefly due. Sometimes the abundance of lime in the lower subsoil gives rise to an almost white color, in which case it is generally impossible to detect even the slightest traces of grit. Again there may be considerable gypsum or concretions of iron compounds, which give rise to the mottled yellow colors. The fact that this heavy substratum has no relation to any limestone formation, being underlain at about 5 or 6 feet by great depths of the slightly gravelly yellow till that underlies a very large part of the area, is *prima facie* evidence that

^a A test by the wire basket method indicated nitrogen as the chief manurial requirement of this soil. The increase in plant growth following the use of a nitrogenous fertilizer, whether nitrate of soda, stable manure, or green manure, was marked, and the use of stable manure or the growing of a legume for green manure suggests itself as the most feasible method of improving this soil.

the lime has been derived from the immediate soil material by the solvent action of soil water and later precipitated under the influence of the special conditions obtaining in the lower soil portion. The subsoil when exposed to the air flakes and crumbles upon drying out, while white alkali at the same time accumulates at the surface. The fine texture and plastic structure offer considerable resistance to circulation of soil moisture and atmosphere.

The Fargo clay is sometimes locally called "gumbo." The soil contains little sand, and if disturbed when too wet, as in the case of wet roadbeds cut up by travel, it becomes very sticky and dries out to a stiff, waxy, and finally extremely hard condition. A clod thus hardened when cut with a knife presents a glistening surface like polished ebony. However, the disintegrating effect of rain causes such hardened masses to crumble down, first into small granules, and then into ordinary fine earth condition. Hot sunshine following rains soon causes a thin surface layer to crack into small polygonal sections. As with the Marshall clay loam, soaking rains with subsequent dry weather causes the soil to bake badly. The occasional prolonged droughts bake the soil so hard that it offers serious difficulty to cultivation—particularly plowing. This is the most difficult of the upland types to manage, and yet in moderately dry seasons careful, timely cultivation secures and maintains good soil tilth. Serious damage from drought has occurred only a few times since this soil has been under cultivation. Notwithstanding these tendencies to assume unfavorable structural conditions in seasons of drought, by far the best results are obtained from the type in dry seasons.

The greater part of the Fargo clay is included in a large body lying to the south and southeast of Mapleton. Several smaller and less typical areas occur outside this main body. As a rule, the surface is so flat that looking out across it, the land stretches away without a noticeable surface inequality, broken only by the windbreaks around farmhouses. There are occasional rises—"step ups"—to higher lying flats, while near the borders of the areas slight undulations may be noticed. The drainage is poor, yet is not so bad as might be expected from the flat surface and the absence of streams. It is probable that were the underlying till a heavy clay instead of a slightly gravelly silty clay the type could not be worked at all without extensive underdrainage. As it is, the crops are uncertain and depend on the season.

This is a late soil, yet the regular crops are grown annually. Within certain limits the drier the season the better the crops. Alkali collects on the surface of depressions in dry weather, but not in injurious quantities. The type probably was covered for a while by water

The absence of sand and all evidences of stratification lend the impression that the water was shallow and that but little drainage was received from the slightly higher surrounding country. It seems probable that there was a stage of marshy, then meadowy, conditions favorable to a heavy growth of grasses and to the accumulation of vegetable remains. This type was a part of the original timberless region.

The Fargo clay is a very strong soil, but without artificial drainage, which as yet has not been more than barely attempted, its true crop value can not be determined. With the inauguration of a thoroughly effective drainage system—large outlet ditches and close tiling—it is reasonable to assume that this would prove the most productive soil in the county. Under present conditions the root systems of plants can not attain normal development, except in dry years. Much of the type is used as hay land. Heavy yields of wheat and corn are secured in dry seasons. Rye is inclined to freeze out, and but little is grown, and clover is also subjected to a certain extent to damage by winter freezing. Excellent garden beets are produced, indicating that forage beets could be introduced profitably in connection with an increase of live stock. Some surprisingly good results have been had with apples, and plums can be grown successfully, but the orchards in general are in need of better drainage, while the apple blight has done much damage. One of the most troublesome questions in grain-growing on this type is the encroachment of weeds upon crops in wet seasons. It is the plan generally to fall plow all grain land on this type of soil to a depth of from 2½ to 4 inches. Experience shows better results with early plowing. On account of the slow circulation of soil atmosphere, organic matter decomposes slowly; hence the necessity of early plowing, so that all possible heat may be turned to advantage in stimulating decomposition. Some plow twice—first early and shallow, so as to promote the germination of weed seed, and then later at right angles to the direction of the first furrow and deep, so as to expose quack grass roots to the action of frost. Even here the less effective practice of plowing in the spring for corn obtains among a few. It happens that now and then the weather conditions prevent fall plowing, especially late plowing following the corn harvest.

A good rotation is: Corn, wheat, oats. Some fields of wheat get so foul with weeds where continuous grain growing has been practiced that the crop is hardly worth cutting. So far grain yields apparently have been lessened more on account of weeds than on account of soil condition. Frequently wheat is grown continuously for ten years or more. Pasturing land for a while is said to improve it. The practice of deep plowing and turning under coarse manures is sometimes followed with profit on this type as it occurs in the Red River Valley,

of North Dakota, suggesting the advisability of testing the practice here. As with the Fargo clay loam, applications of barnyard manure benefit despite the very high original organic matter content of the soil.

The prosperity of the farmer is not as evident here as on the better-drained soils. The land is not valued as high as the adjoining more rolling type, but ranges from \$40 to \$50 an acre.

The following table gives the average results of mechanical analyses of the Fargo clay:

Mechanical analyses of Fargo clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
15402, 15404	Soil.....	0.2	1.7	3.5	8.8	2.6	44.5	38.6
15403, 15405	Subsoil.....	.2	1.0	1.4	5.9	2.7	42.0	46.1

The following samples contain more than one-half of 1 per cent of calcium carbonate (CaCO_3); No. 15403, 3.7 per cent; No. 15405, 8.4 per cent.

MARSHALL FINE SAND.

The soil of the Marshall fine sand is a light-brown to nearly black fine sand 15 to 24 inches deep, usually with an average depth of 22 inches, having a slightly loamy feel. The subsoil is a light-brown to orange, loose, incoherent fine sand to a depth of 30 inches, where it generally passes into a yellow fine sand. Occasionally the subsoil of small hillocks and higher ridges consists of a gravelly material. The soil and subsoil of the swales are frequently black and loamy, owing to the poorer drainage and washing in of fine material from slopes.

About 75 per cent of the type occurs in the townships of Garden City and Lincoln, in a belt about 2 miles wide, following the northern bank of the Watonwan River for a distance of 9 miles. There are several small bodies touching the southern bank of the river. In this main belt the topography is undulating to gently rolling and hummocky. Just north of this main body are several small rounded or oblong, almost flat to hummocky areas of this type, closely associated with and lying at from 1 to 10 feet above the surrounding Fargo fine sandy loam. In these the water table is generally quite near the surface, maintaining a good supply of moisture. To the east and north of Lake Crystal are several gently rolling areas conforming closely with the general topography of this section. While the type as a whole is not sufficiently retentive of moisture in dry seasons, it is not nearly so much inclined to suffer from drought as fine sands carrying less organic matter.

The type is of glacial origin, though its exact manner of deposition is not clear. There are evidences that the low-lying hummocky areas have been blown up from the old lake bed of Fargo fine sandy loam.

Possibly the wind has had considerable to do with the formation of the soil. Again, it seems probable that water action in crevices of the ice may have brought about these irregular depositions. Oak of a heavy growth is the predominant tree in the fringe of timber along the streams and around lakes. Most of the type comes under the head of prairie land.

The Marshall fine sand is used for general farming. Its yields are affected greatly by the seasons. Good crops are made in wet years. The average yields are less than those of the heavy types having fair drainage. Corn yields from 25 to 45 bushels per acre; wheat, from 8 to 18 bushels, and barley, oats, rye, grass, and flax give medium to good yields, according to the season. This soil grows much better clover than the general run of sands. It does not winterkill so badly as on the heavier soils. The loamy, wet depressions produce good millet, buckwheat, and flax, though but little of these is sown. The type is ideally adapted to potatoes, growing a white-mealy potato of good flavor and keeping quality. It is also an ideal vegetable soil. Should general farming ever reach a point of little profit, excellent opportunities for specialization would be afforded here. Cantaloupes, watermelons, and cucumbers for pickles undoubtedly would prove profitable specialties. The soil should be well adapted to sugar beets. Fall plowing is not so necessary with the Marshall fine sand as with the heavier soils, yet it is evidently advantageous to plow in the fall where green vegetable matter, as grass or clover, is to be turned under. Plowing should be done early to get a growth of vegetation for a cover crop or soil binder. Considerable injury from blowing is likely to follow plowing in dry seasons, and some farmers cover their fields with straw to prevent this. Manure spread over the surface also helps to bind the soil, and farmers generally use more care in saving and applying barnyard manure here than on other types where manure is not so badly needed. Shallow cultivation is the rule and is more to be recommended than on the heavier types. Turning under green crops on a more extensive scale is strongly advised. The best rotation would include clover or a grass-clover mixture to be turned under green at intervals best determined by actual field tests. A rotation that would seem suited to the type is: Corn, wheat, oats or barley, clover or a clover-grass mixture, to be turned under in the late summer of the second or third year. Rye turned under in the spring is of considerable benefit. It is thought this would be a good practice preceding potatoes. Buckwheat also may be used as a green manure crop. Frequently grain is put in on corn land without previous preparation.

Farmers should make special effort to keep as much live stock as possible for the reason that this soil needs heavy applications of

barnyard manure.^a It is advised that the acreage of wheat and flax, and in fact of all general farm crops except those that can be fed to the farm stock, be decreased. The low wet places should be tiled wherever possible.

By raising stock and carefully managing the soil many farmers are making a success. The land is held at about the same price as the neighboring heavy types, although it is not so generally sought after by those unfamiliar with the good average crops to be secured by judicious management of this type of soil.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Marshall fine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
15430.....	Soil.....	0.0	1.3	5.5	64.7	9.3	10.8	8.3
15431.....	Subsoil.....	.0	1.0	5.4	69.7	10.7	6.9	6.2

MARSHALL FINE SANDY LOAM.

The soil of the Marshall fine sandy loam, to an average depth of 18 inches, consists of a dark-brown to nearly black, mellow, fine sandy loam carrying much organic matter. The subsoil is a light-brown or pale-yellow fine sandy loam or fine loam frequently resting on a yellowish silt loam at a depth of about 2 feet. Occasionally a gravelly material consisting of rounded pebbles, fragments of rock, and sand is encountered within a few inches of the surface. This type of soil may be tilled easily and under a wide range of moisture conditions without danger of baking or of the formation of clods.

The Marshall fine sandy loam is confined mainly to the upper slopes of the Blue Earth and Watonwan River valleys and the country to the north and west of these. Along the rivers it occurs as rolling land confined to the gradual slope from the main upland level to the bluff line and as shelflike terraces rarely descending as low as 40 feet above the stream bed. In the neighborhood of Solberg Lake and the lakes around the town of Lake Crystal the topography varies from nearly flat along the lake shore to gently rolling farther out in the prairie. In Lincoln Township the type occurs as ridges,

^a Work in the laboratory upon this soil, using pot cultures, indicates the great superiority of both stable manure and green manure over commercial fertilizer. It follows that the most feasible plan of improving the type consists in husbanding and carefully applying all stable manure made upon the farm, and in the adopting of a rotation arranged to include a green manuring crop, preferably a legume. Such a course will maintain the organic content of the soil and keep the soil in the best possible mechanical condition for the absorption and retention of moisture.

small hills, and gently rolling land. At Pleasant Mound there occurs a gravelly phase in the form of a kame or mound-shaped hill, which rises rather abruptly to about 75 feet above the general level. There are several small areas of the same phase in the surrounding low hills or ridges. The type is well drained and crops suffer but little from wet weather and generally not a great deal in droughts.

This soil in the prairie country was derived from glacial material in a manner very much the same as was the Marshall fine sand. That along streams undoubtedly owes its origin, in part at least, to the action of the water currents that cut through the till to form the present valleys. The timber growth bordering stream courses and lakes consists principally of oak and maple.

The Marshall fine sandy loam is well adapted to fruit, particularly in the areas adjacent to streams. Here is found a soil well suited to apples, cherries, plums, raspberries, blackberries, and strawberries. Potatoes of good quality, beets, cabbage, onions, cantaloupes, watermelons, cucumbers, and other vegetables can be grown very successfully. Besides possessing properties suiting it to fruit raising and market gardening, this soil produces good yields of the general farm crops, nearly as good yields as the Marshall silt loam in years of moderate and well distributed rainfall. However, the yields drop below this in dry years. Its sandy texture and open structure permit the surplus water to drain away quickly, making it an early and easily managed soil. Weeds are not so troublesome and can be destroyed easier than on the heavier types. The rotations suited to Marshall silt loam are also suited to this soil, but generally it should be the plan to turn under more organic matter. The farmers on this type of soil are generally prosperous. The land is held at \$45 to \$60 an acre.

The following table gives the average results of mechanical analyses of the soil and subsoil of the Marshall fine sandy loam:

Mechanical analyses of Marshall fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
15420, 15422.....	Soil.....	0.5	3.2	5.7	41.6	8.4	23.6	16.7
15421, 15423.....	Subsoil.....	.5	3.9	6.6	44.6	8.4	20.2	15.9

MARSHALL LOAM.

The soil of the Marshall loam has a depth of from 12 to 16 inches and consists of a dark or nearly black rather heavy but mellow fine loam with good organic matter content. This is underlain by a dark-brown to light-brown heavy fine loam or by a yellow silt loam. Frequently, as in the case of the other light upland types, a gravelly

sandy material is encountered at a depth of from 10 to 20 inches. This type is not very uniform in texture, but blends so imperceptibly with the Marshall fine sand on the one hand and the Marshall silt loam on the other that the boundary lines can be drawn only with much difficulty. The soil is easily broken and cultivated.

The Marshall loam is almost entirely confined to the northwestern part of the county, a large part of the type being included in the large continuous area around Lake Crystal. There is also quite an extensive occurrence in the vicinity of Solberg Lake, and several small irregular bodies occur here and there in the section west of the Blue Earth and north of the Watonwan River. The vegetation and the topographic and drainage features are about the same as those of the Marshall fine sandy loam. The type is derived from glacial material.

The Marshall loam is adapted to about the same class of crops as the Marshall silt loam, though it is not quite so well suited to wheat and grass. Because of the lighter texture, better natural drainage, and greater ease of cultivation it is adapted to a wider range of crops than any of the heavier types. Good yields of sugar beets can be produced, and potatoes of good keeping qualities are grown. The average yields of the general farm crops are nearly equal to those of any of the upland types. Wheat yields from 12 to 25 bushels, corn from 35 to 55 bushels, and oats 40 or more bushels per acre. Clover does well and is important in a good system of rotation. Alfalfa, it is believed, would also do well. In general, the agricultural methods suited to the Marshall silt loam—the depth of plowing, rotation, and cultivation—are equally applicable to this soil. More thorough spring preparation can be practiced advantageously, particularly in ridding the land of weeds and in enabling the early planting of corn.

The most successful farmers save and apply carefully all the barnyard manure. Their aim is to manure corn land at least once in five years. Turning under clover, buckwheat, and other green crops greatly benefits the land, and rotations should be planned to include some green manuring crop at least once every five years. This soil is very desirable and commands good prices, and the farmers situated on it show every evidence of prosperity.

The following table gives the average results of mechanical analyses of samples of the soil and subsoil.

Mechanical analyses of Marshall loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
15416, 15418.....	Soil.....	0.9	10.3	9.0	17.8	9.1	41.4	10.9
15417, 15419.....	Subsoil.....	.8	14.9	9.0	16.3	10.1	33.2	15.1

FARGO FINE SANDY LOAM.

The soil of the Fargo fine sandy loam, to an average depth of about 2 feet, consists of a black mucky loam to fine sandy loam carrying a very high percentage of organic matter. In the first 8 or 10 inches there is usually so much vegetable matter that the soil is like muck. In some places fine material washed from neighboring slopes and intermingled with the soil along the border has given rise to narrow strips of loam or clay loam. Such nonconformities are not found in sufficient extent to warrant their separation as distinct types. The subsoil is a grayish mealy fine sandy loam which generally becomes yellow or grayish yellow at about 3 feet. This lower portion of the subsoil is often mushy and tends to flow or spread out when not obstructed, and hence is locally called "quicksand." This tendency to flow makes it extremely difficult to keep ditches open. The sand runs out from beneath the more solid upper soil and spreading over the ditch bottom keeps it filled up nearly to the upper level of the subsoil. There is an appreciable amount of medium-textured sand in this subsoil.

The type is distinctly local in its occurrence, being found in one large continuous body, with several lesser outliers, in the townships of Lincoln and Garden City, southwest of the town of Lake Crystal. The characteristic topography, as represented in the main body, is that of a low, flat stretch of land interrupted by hummocks, hillocks, and narrow winding ridges of Marshall fine sand lying from 1 foot to 15 or more feet above the general level. There are slight, almost imperceptible, depressions or Meadow areas here and there. Looking across this large body these minor surface irregularities are so indistinct that the land stretches away apparently perfectly flat, interrupted only by an occasional mound of sand, which sometimes supports a dense growth of boxelder, cottonwood, willow, hazel bush, etc.

The natural drainage is so inadequate and artificial drainage so difficult—both on account of the unstable nature of the subsoil and the lack of outlets—that this is by far the least desirable soil of the area. Drainage outlets could be reached by carrying ditches in rather tortuous courses to certain points along the southern boundary of the main body, where the distance to the Watonwan River is from one-half to 1 mile, and cutting through the Marshall fine sand from these points to the river. Along the western boundary there are easy approaches to stream outlets, and some of the smaller areas are more accessible to natural outlets. To make effective ditches would require the cooperation of all the farmers and possibly the county and township. Careful surveys would be absolutely necessary, while it is probable some experimental work near a stream outlet in the western

part of the main body would be a wise step, in order to determine the effectiveness of various plans for drainage construction.

The Fargo fine sandy loam is of lacustrine origin. Its topography and soil features show distinct evidences of the existence of a former shallow lake quite similar to some of the present lakes, which have flat sandy bottoms. Since the old lakes have dried up, wind action has slightly altered the lake bottom by blowing the sand up into mounds, hummocks, or ridges.

When well drained, good crops of corn and fair crops of grain, particularly barley, can be secured. Potatoes, flax, buckwheat, rye, and wheat will do very well with good drainage. Some heavy yields of hay are produced. A large proportion of the type supports a growth of native grasses, slough grass, flags, cat-tails, and rushes, and most of it is now used for hay and pasture land.

The following table gives the average results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Fargo fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
15400, 15406.....	Soil.....	0.1	3.9	8.2	41.4	6.9	23.9	15.5
15401, 15407.....	Subsoil.....	.1	3.1	10.0	55.2	6.5	13.2	11.7

The following samples contain more than one-half of 1 per cent of calcium carbonate (CaCO_3): No. 15400, 8.8 per cent; No. 15401, 8.9 per cent; No. 15406, 16.1 per cent; No. 15407, 5.7 per cent.

WABASH SILT LOAM.

The Wabash silt loam consists of a black silt loam or heavy fine loam, underlain at a depth of 20 inches by a dark-colored material of variable texture, which may be either a silt loam, loam, clay loam, or even a fine sandy loam. Along the Minnesota River the soil is a silt loam, while the subsoil is either a plastic, heavy silt loam or a fine sandy loam. The soil of those areas included within the Marshall clay loam belt varies from a heavy fine loam to silt loam, and the subsoil varies from a loam to clay loam or, in the lower depths, to clay. The texture depends largely upon the character of the soils of the respective drainage basins. The heavy phases are inclined to bake and crack in seasons of drought, but the high organic matter content has a tendency to prevent the formation of durable clods. The type is free from rocks of all kinds. In seasons of normal rainfall cultivation is easy, but when the heavier phase is permitted to remain undisturbed in dry weather a very intractable structure is apt to ensue. Excellent tilth is maintained with seasonable treatment.

The Wabash silt loam occurs as first bottom land along the larger

water courses. The greater part of the overflow land of the Minnesota River west of the point of confluence with the Blue Earth consists of this type. Here the areas vary in width from a few rods to about three-quarters of a mile. A large part of the first bottom land lying within the general Marshall clay loam area is Wabash silt loam. The most extensive areas occur in the concaves of bends, the convex sides of which generally are precipitous and without first bottom land. The valleys of some of the lesser streams have not been cut very deep, particularly those of Big and Little Cobb rivers, and the bottom land, or Wabash silt loam, sometimes slopes away from the river and rises gradually to blend with the Marshall clay loam or Fargo clay without intervening bluff lines or distinct boundaries.

The type is level or nearly level. There are frequent sloughs and ponds in the abandoned stream beds left upon a shifting of the stream channel. A notable example is the long, narrow pond, or lake, in the bottom east of Judson. In a number of places in the Minnesota River bottom these ponds and sloughs cut across the bases of bends and thus leave the land back in the bends practically inaccessible.

While very nearly all the Wabash silt loam is subject to overflow, these overflows occur so seldom that comparatively little damage is done to crops. The natural drainage is good; still, tiling would improve much of the heavier bottom land. This could be done at comparatively little expense on account of the nearness to a good outlet. Crops very rarely suffer from drought.

The Wabash silt loam is alluvial in origin, having been built up by repeated deposition of the fine material carried in suspension by flood water. The native vegetation is mainly ash, boxelder, elm, maple, beech, and birch.

The Wabash silt loam is an excellent corn and oat soil. Rye and barley do well on the lighter phase, while wheat does very well on the heavier. The cultivation of corn, wheat, and oats constitutes the chief agricultural use of the soil. Some remarkably heavy yields of native grasses are secured, but little is grown on account of the profitableness of the grain crop. Corn yields year after year, without manure, from 40 to 70 bushels; wheat from 15 to 25 bushels, and oats from 40 to 65 bushels per acre. The soil does not seem to deteriorate from continuous cropping. Little or no attention is paid crop rotation, and manure is applied but seldom. Fall plowing is done about as on the upland types, when the season permits.

Farms in the southern part of the county, including this type, generally also include a larger area of upland, so that acreage valuation is not materially affected by it. In the Minnesota Valley, however, there are several valuable farms situated almost entirely upon this type.

The following table gives the average results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Wabash silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
15452, 15454.....	Soil.....	0.0	0.5	0.2	8.7	18.6	56.1	15.7
15453, 15455.....	Subsoil.....	.1	.4	.3	10.7	20.2	52.1	15.8

WABASH FINE SANDY LOAM.

The soil of the Wabash fine sandy loam consists of a brown to black light fine sandy loam 15 to 24 inches deep, with an average depth of 20 inches. The subsoil is a lighter colored and generally heavier fine sandy loam. Variations in both soil and subsoil are frequent. In depressions and swales the soil is generally darker colored and heavier, sometimes closely approximating a silt loam to a depth of 3 feet or more. On the other hand, numerous small areas of a deep fine sand—Wabash fine sand—have been included with the Wabash fine sandy loam because of their limited extent. The type usually is lightest next the stream bank.

Barring delays in preparation and cultivation occasioned by somewhat rare and exceptional overflows, this is the most easily managed soil in the area. The texture admits of easy cultivation, and rotation, fall plowing, and other cultural details employed on the best managed of the upland soils are relatively not of so much importance here.

The type occurs as first bottom land along streams, and occupies a corresponding position and has about the same topographic features as the Wabash silt loam. Owing to slight depressions and elevations here and there the topography sometimes is gently undulating or hummocky. While most of the type lies at from 10 to 25 feet above the level of the streams and is subject to overflow, some of it farthest away from the stream, is above the overflow zone. The type occurs most extensively along the Blue Earth, Watonwan, and Le Sueur rivers. Its natural drainage is excellent and most of the area is cleared and under cultivation.

The Wabash fine sandy loam is an alluvial soil derived from materials laid down by overflow water. The texture of the upland soils of the immediate drainage basins, from which the more recent bottom land soils have been derived by wash, largely determines the texture of these bottom lands. The native vegetation consists for the most part of maple, ash, boxelder, elm, beech, and birch. Wild grape and other vines are quite abundant.

The soil is particularly well adapted to corn, producing year after

year, without manure, from 40 to 70 bushels per acre. Oats, rye, and barley also find an especially favorable environment. The higher lying, better drained areas are well suited to vegetables. Sugar beets have been grown successfully. Potatoes of good keeping and shipping qualities can be grown with profit. Onions do exceptionally well and should be grown more extensively.

The type affords opportunities for the pursuit of highly specialized lines of agriculture. The area included under a single farm is rarely extensive. It would seem that its presence should enhance the value of a farm by reason of the good opportunities for diversification it affords.

Light applications of barnyard manure are sometimes made. Fall plowing is most beneficial in destroying a crop of weeds and in aiding the decay of vegetable refuse.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Wabash fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
15448.....	Soil.....	0.2	2.8	4.8	36.7	21.2	25.4	8.4
15449.....	Subsoil.....	.3	3.1	5.8	42.1	23.8	17.1	8.3

The following samples contain more than one-half of 1 per cent of calcium carbonate (CaCO_3); No. 15448, 4.2 per cent; No. 15449, 5.9 per cent.

MANKATO SAND.

The Mankato sand consists typically of a medium to fine brown or nearly black slightly loamy sand, resting at about 2 feet upon a yellowish medium to fine sand which frequently becomes gravelly at a depth of about 3 feet. In an exposed section 25 feet thick, the only differences noted from top to bottom are a slightly lighter color with increasing depth and a higher gravel content below 3 feet.

There are three areas of this type of soil in the Minnesota River Valley west of Mankato. The largest—a body about 2 square miles in extent—occurs in the township of Cambria. This is known as the “Little Prairie” and lies at an altitude of from 100 to 150 feet above the river. The body just west of the mouth of the Blue Earth River lies at about the same altitude and has a slope to the west, away from the river. There is a flat area containing little or no gravel, about 2 square miles in extent, north of Mankato in Lime Township, lying at an elevation of about 75 to 100 feet above the river. There are also several small low-lying areas along the Blue Earth and Maple rivers.

The type is used for general farming. It will yield in years of normal rainfall 50 bushels of corn and from 10 to 18 bushels of wheat per

acre. With its good drainage the soil warms early in the spring, making it well suited to the production of early vegetables and market garden crops. Potatoes of good quality and early sugar corn can be grown. Experiments were made with sugar beets on this soil about 1899. Fair yields of good quality beets were produced, but owing to certain misfortunes with the growing crop, distance to factory, trouble in disposing of the crop, and other economic drawbacks the experiment proved unprofitable and the crop was abandoned.

Barnyard manure is applied every two or three years. Heavy applications of manure and occasional turning under of green manure are necessary to secure the best results.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Mankato sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
15444.....	Soil.....	0.4	11.3	20.5	42.6	5.9	8.8	6.9
15445.....	Subsoil.....	.4	9.2	19.5	50.5	6.5	7.0	7.2

MANKATO SANDY LOAM.

The Mankato sandy loam consists of a brown to dark-brown medium to fine sandy loam, underlain at an average depth of 15 inches by solid bed rock. Usually 2 or 3 inches of the material directly overlying the bed rock is a reddish-brown fine loam. In some places the soil is 2 feet deep while in others it is only a few inches deep, and in places the bed rock outcrops. Some small areas could have been classed as a loam, but were not outlined on the map because of their limited extent and irregularity of occurrence. Generally the shallower the soil the more loamy the texture. The underlying rock is either Shakopic limestone or Jordan sandstone. Granitic and gneissic boulders from 1 to 6 feet or more in diameter are scattered quite thickly over the surface in some localities, but as a rule do not interfere seriously with cultivation.

This is a local type of no great agricultural importance, because of its limited occurrence and shallow depth. There are several areas in the valley north of Mankato and a long strip 1 square mile in extent beginning on the high terrace one-half mile east of the mouth of Minneopa Creek and extending 2 miles westward. The soil occurs in the Minnesota River Valley on high terraces, lying at an elevation of from 100 to 150 feet above the river. The terrace in South Bend Township slopes gradually westward and is inclined to be undulating in topography. North of Mankato the type is almost level.

The Mankato sandy loam owes its origin to deposition of sand from the waters of the Minnesota River before it had opened up the deep valley below. The thin sheet of brownish material in the lower profile is derived from the underlying rocks.

The type is quite droughty. Light to fair yields of corn and of small grains are secured, the yields depending upon the depth of soil and the character of the season. The soil makes excellent pasture in wet and moderately wet seasons. Those spots where the sand is deepest could be utilized for market gardening. The soil warms early in spring and this favors the production of early vegetables such as radishes, lettuce, peas, sugar corn, etc.

The type is low in organic matter as compared with some of the other types of the area. Heavy applications of manure at frequent intervals are necessary to get the best results. For the same reason green manuring should be practiced, especially where the supply of stable manure is limited.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Mankato sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
15414.....	Soil.....	0.6	11.2	13.0	28.3	9.1	30.8	6.7
15415.....	Subsoil.....	.4	16.2	23.9	31.1	6.6	15.4	6.6

JUDSON LOAM.

The soil of the Judson loam consists of a mellow black loam, varying in depth according to position. It occurs either along the gentle slopes of the stream valleys or near the foot of these slopes. In the most extensive areas, those along the upper valley wall or bluff of the Minnesota River, much of the type occurs near the base of the bluff as imperfectly developed cone-shaped deltas. Here the soil is an extremely productive mellow loam 3 feet or more deep, the depth becoming less as the upper or more inclined part of the slope is approached. In some places the soil consists of only a few inches of black loam. The subsoil is a yellowish-brown clay loam or unaltered glacial till.

The Judson loam is colluvial in origin, and represents materials washed down from the uplands and mixed with the material of the deep underlying till which is exposed on the slopes. The texture, drainage, and position admirably suit this type of soil to fruit, particularly apples. Some excellent apples are already grown on the gentler slopes, but the soil has not been recognized by many as being

especially suited to fruit or, if it has, but little effort has been made to follow up the adaptation. But a small proportion of its area is under cultivation, the greater part supporting a growth of walnut, butternut, beech, birch, elm, basswood, maple, and other trees. Some of the best yields of corn and wheat have been secured from the lower, more nearly level areas of this type. Fine cabbage and good potatoes can be grown on it. Great care should be exercised in clearing the more inclined slopes, lest serious erosion follow. A large part of the type is not well suited for other purposes than orcharding.

The following table gives the results of mechanical analyses of a sample of the Judson loam:

Mechanical analyses of Judson loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
15408.....	Soil.....	0.9	5.6	5.7	28.2	12.3	31.8	14.5
15409.....	Subsoil.....	1.3	5.4	5.6	28.8	12.5	28.5	17.2

MANKATO LOAM.

The soil of the Mankato loam is a heavy stiff black loam to clay loam from 1 to 2 feet in depth, and rests directly upon bed rock of limestone or sandstone. A few inches immediately overlying the bed rock is reddish brown in color and sandy in texture. Groups of gneissic and granitic boulders varying from 1 to 6 or more feet in diameter occur in places so thick as to render the soil unfit for anything but pasture.

Like the Mankato sandy loam, this is purely a local type. There is an area of about 3 square miles in the long narrow strip, occupying second and third terraces included in the second bottom of the Minnesota River, extending from the small stream just west of Judson Station eastward for a distance of approximately $4\frac{1}{2}$ miles. These terraces range from the level of overflow, between Judson Station and the river, to an elevation of 60 feet above the stream bed at the highest point. The average elevation is considerably lower than that of the Mankato sandy loam. Just east of Judson Station there is a slope in the surface of the higher terrace away from the river toward the bluff line so that along the foot of the bluff there is a long well-developed depression or swale, probably the old bed of the river. In this depression the soil is 3 feet or more deep and poor drainage conditions prevail.

The type is of residual, alluvial, glacial, and, to a lesser extent, colluvial origin. The lower part of the profile, which has a reddish-brown color, has been derived directly from the underlying bed rock.

The Mankato loam is subject to extremes of moisture conditions. In wet seasons much trouble is experienced in cultivating it, necessitating the use of a large part for hay or pasture land. On the other hand in seasons of drought crops suffer badly for lack of moisture. With favorable seasons good crops of corn are grown, though the soil is best adapted to wheat.

The following table gives the average results of mechanical analyses of samples of the soil of this type:

Mechanical analyses of Mankato loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
15412, 15413	Soil	0.9	4.1	3.8	11.4	15.5	51.2	12.8

MEADOW.

About four-fifths of the Meadow areas represents very poorly drained depressions in the upland. The topography and character of the soil material show that most of these are the beds of old lakes, many of which have dried up or partially dried up since the settlement of the county, when the water supply or drainage from surrounding slopes was cut off or lessened through the increased absorption of rainfall by the cultivated land. The wet conditions in these depressions has favored the growth of water-loving plants such as flags, cat-tails, rushes, slough grass, etc. Accumulations from these plants have developed mucky conditions in the type and not infrequently several inches of peat is found on the surface. Here the Meadow consists of 8 to 15 inches of a black soil, containing much decomposed and partially decomposed vegetable matter, resting upon a black or blue-black clay or upon a sandy loam or interstratified layers of sand and clay. In other places the Meadow merely represents a soil condition, and with better drainage would probably be recognized as Fargo clay loam, Marshall loam, or Fargo fine sandy loam. The Meadow mapped along streams is generally quite variable in texture and contains considerable sand. Many of these variations can be recognized as distinct soil types, yet the variations occur so frequently that for the most part uniform areas are too small to permit of mapping on the scale used in this survey.

Some of the Meadow type produces very heavy yields of good hay, while with good artificial drainage it is admirably suited to corn. In view of the good yield of wild hay, it would not prove particularly advantageous to drain all the type with the aim of cultivating it. However, much of it with better drainage would grow more grass, while at the same time the use of mowing machines could be extended.

Too large a proportion of the total land area of a number of farms is included in this type, particularly in the northwestern part of the county.

PEAT.

Peat consists of partially decomposed vegetable matter—the accumulated remains of water-loving plants. These deposits largely occupy the beds of former lakes. The material represents the roots, leaves, fibers, etc., of cat-tails, rushes, flags, moss, grass, and, to a lesser extent, weeds, laid down in water or just above saturated material, so that decomposition has been retarded by water and by the protection afforded through subsequent annual deposits. Being thus only partially decomposed, the material has retained the fibrous structure of the plants. Near the borders, where decomposition has advanced further and where soil washed down from the surrounding slopes has been intermingled with the vegetable matter, are found some narrow strips of Muck. Many of the small lakes are being slowly filled with Peat. The plants, starting at the shore, build up deposits upon which they grow out farther into the lake, and this process continued through ages, gradually work toward the center, filling the lake to the water surface with Peat. The deposits vary in depth from about 20 inches to 6 feet or more and are usually underlain by a bluish-black clay, sometimes containing small concretions of lime.

The most extensive occurrence of Peat is in the lake region of the northeastern part of the county. There are isolated areas here and there throughout the county, but very little of it occurs outside the section lying north of the Le Sueur River. Small shallow deposits of Peat have been included with many Meadow areas. There is a peculiar occurrence of Peat in the valley of the Minnesota River in the western part of South Bend Township. Here there is a strip about 3 miles long and only a few rods wide lying along the foot of the bluff at an elevation of from 15 to 40 feet above and sloping toward the river. This deposit is usually very deep. In order to firm the roadbed of the Northwestern Railroad, which is built on this strip, it has been necessary in places to drive piles into this material to a depth of 40 feet. Water-loving plants, chiefly mosses, cat-tails, rushes, and slough grass have found a most favorable environment in this position on account of the numerous perennial springs that flow out of the bluff wall, and by annual deposition repeated over a very long period have built up this deep peat bog.

While some good crops of corn have been grown on well-drained areas of Peat, but little of the type has ever been used for other purposes than pasture or hay land. Better drainage would greatly enhance the value of Peat for the production of hay, as it would

tend to destroy the growth of cat-tails and rushes and favor the development of wild meadow grasses. Some enormous yields of good hay are secured annually from areas sufficiently firm to support mowers and horses. While good corn and fair yields of small grains can be grown on this type of soil, it is not likely that the average quality would come up to that of the better soils. Grain tends to go largely to straw and lodge. It is advised that experiments be made with onions, cabbage, and celery. Some heavy yields of these crops have been grown on fairly well-drained and decomposed Peat in various parts of the United States.

DRAINAGE.

The recent succession of "wet years" has brought before the farmers the extreme importance of the problem of drainage, though as yet few have taken active steps, many waiting the return of normal "dry years," believing artificial drains will then be unnecessary or even harmful. Some tiling is being done here and there—most extensively, perhaps, in the flat lands in the southern part of the county.

The types most in need of drainage are: The Fargo clay loam, a considerable portion of which excellent soil is too late for general crops or too wet for cultivation except in dry seasons; the Fargo clay; the Marshall clay loam, and the Fargo fine sandy loam, which last is largely too wet for cultivation. Throughout the county there are small flat areas, depressions, small lakes or ponds, peat bogs, and sloughs that need tiling or drainage outlets. Many lesser streams should have their carrying capacity increased by being straightened and enlarged.

The poor drainage conditions are largely due to a combination of unfavorable topography and impervious subsoils, though in many cases the trouble is solely due to lack of an outlet. The conditions plainly indicate that the quickest, most effective, and most permanent results are to be procured by the use of tile drains, installation of which over most of the area concerned would necessitate the construction of open main ditches as outlets. While much can be done by individuals, it rests upon public-spirited cooperation among the farmers of a community or upon the county authorities to handle effectively the problem in its large scope. Methods for constructing main ditches are provided for by statute. Upon petition of a certain percentage of landowners of a community county officials may order the construction of mains. Assessments to cover the cost are apportioned against landowners as nearly as possible in proportion to benefits accruing to their respective holdings.

Some quite effective ditches have been dug by contractors using rolling steam shovels. Ditches have not come up to expectation in

some instances, probably on account of insufficient depth; in others because of peculiarities of the soil structure. Main ditches should follow the course of natural drainage so far as is practicable. In level areas like that of the Fargo clay they could be built along the public highways, serving at once to improve roads and land. The Clyde fine sandy loam presents a serious drainage problem in the peculiarity of its subsoil structure. In open ditches the loose quicksand of the subsoil flows into and fills the channel. Outlets for drains from this type should be carried to the Watonwan River or by way of the natural outlet in western Lincoln Township.

Depth and proximity of laterals and size of tiling should be determined by tests or so far as possible from the experiences of others. Single lines have been sufficient to drain sloughs, lakes, and fields of considerable size having a slope toward the drainage way in general. All soil should be brought within active range of laterals. For the Fargo clay this probably would require tiles to be laid 40 to 75 feet apart. Most tiling is being done by contractors.

Except in a very general way many farmers seem unfamiliar with the effects of underdrainage. Since the surface of the water table is the limit of healthy root development, a lowering of this ground water by underdrainage serves to deepen the soil. With the removal of such water the soil warms up earlier in the spring, making the planting season earlier and consequently the growing season longer. The stiff, heavy soils are made more open and friable, allowing easier cultivation and promoting the absorption of rain water and the circulation of soil atmosphere and moisture, processes favorable to plant growth. The effects of drought are diminished, owing to a more widely distributed root system throughout the deepened soil, the freer movement of soil moisture, and the prevention of excessive evaporation by the favorable condition of soil structure.

In brief, thorough underdrainage secures greater certainty, better yields, and better quality of crops and constitutes an improvement permanent in character. The condition of land with respect to drainage conditions is already a factor in determining the value of land, and in the near future bids fair to influence prices in such a way that no farmer can afford to neglect the drainage of his land.

SUMMARY.

Blue Earth County is situated in central southern Minnesota about 150 miles west of the Minnesota River and nearly 90 miles southwest of Minneapolis. The total land area is 479,104 acres and about 22,000 acres more are water surface. About five-sixths of the county is flat to gently rolling prairie interrupted by sloughs and small lakes and by the deep valleys of a system of rivers which

flow across the county, converge toward the north-central part, and finally empty into the Minnesota through the Blue Earth River. The section north of the Le Sueur and west of the Blue Earth rivers, originally heavily timbered land, is flat to hilly and contains many lakes. The altitude of the upland averages about 1,000 feet above sea level. The stream valleys vary in depth from 30 to 225 feet.

The climate is healthful, though subject to a wide range in temperature. The extreme maximum range is about 139° F., the normal annual temperature about 45°, while the normals for January and July, the coldest and warmest months, are about 13° and 74° F, respectively. About 80 per cent of an annual precipitation of 26 inches falls in the seven warmer months, April to October, inclusive. Natural drainage is good in the more rolling soils. A large proportion of the land needs underdrainage, while many sloughs and depressions can not be cultivated without extensive drainage, except in dry seasons.

The population of the county in 1899 was 32,000, composed of Americans, Germans, Swedes, Norwegians, and Welsh, named in order of relative numbers. Practically the entire area is under cultivation. Most of the sloughs and depressions produce heavy yields of "slough grass" or other wild grasses. A native bluegrass furnishes good pasturage in a few rough broken localities.

Transportation facilities are excellent. The county has four railroad systems, which are so distributed that very few farmers have to travel more than 10 miles to reach a market or grain elevator. The county roads are generally good in late summer, fall, and winter, but become sticky and almost impassable in low places after a spring thaw.

Named in the order of importance, wheat, hay, corn, oats, barley, flax, and rye comprise the general farm crops. All the wheat and flax, most of the rye, and considerable of the barley is shipped. The larger part of the hay, corn, and oats and considerable of the barley is used on the farm to supply feed for the live stock. Very little systematic rotation has been practiced, and continuous cropping to wheat has in some cases caused the soil to decline in productiveness. Troublesome weeds—mainly quack grass, wild oats, and mustard—have become serious pests.

Productivity can be maintained or restored and weeds kept down best by decreased production of wheat, increased production of corn or other clean-cultivated crops, deeper plowing, and systematic rotation.

The best rotation followed at present is: Corn, wheat, oats, or barley, followed by two or three years of grass, clover, or a mixture of the two to be cut, grazed, and finally turned under green.

No commercial fertilizers are used. Barnyard manure sometimes

is carefully saved and applied to corn and grass with excellent results. Generally not more is made than enough to cover the fields once in about four or five years.

The soils are well adapted to general farm crops. Farmers recognize one soil as being more productive than another, but pay little attention to differences in adaptation. Small experimental crops of alfalfa, sugar beets, and feed beets have shown that the deep, well-drained mellow soils are adapted to these crops.

The price of land varies from \$45 to \$75 an acre, depending upon the location, the type of soil, condition of barn buildings, and the drainage. Land is rented to share tenants for one-half the crops and to cash tenants for from \$2 to \$3.50 per acre. About 70 per cent of farms are operated by their owners. A large proportion of rented farms are operated by share tenants.

Fourteen distinct soil types, exclusive of Peat and Meadow, have been mapped. These vary in texture from sand to clay, but a very large proportion of the area is made up of heavy clay loams and clays. The absence of rocks and the gentle lay of the land adapt the soils to the use of improved farm machinery. The high organic matter content admits cultivation under an unusually wide range of moisture conditions.

The Marshall silt loam is a gently rolling and fairly well-drained type. It is used for general farming and at present is producing the best average yields of corn, rye, barley, and hay of any of the upland soils. Apples, plums, cabbage, onions, and potatoes do well in the better drained places. Small fruits—raspberries, blackberries, and strawberries—of excellent quality can be grown with good drainage, especially in the rolling sections near streams. The type is adapted to clover, alfalfa, feed, and sugar beets.

The Fargo clay loam occurs as flat lowland generally representing the bed of an old lake. The type is so poorly drained that a large proportion can be cultivated only in dry years. When well drained this is the best corn soil in the area. Wheat and oats are inclined to go too much to straw.

The Marshall clay loam is flat to undulating and is the most extensive type of the area. The drainage varies from poor to fair. The best crops are grown in a moderately dry season. While this is the the most extensive wheat and oat soil of the area, corn, barley, hay, and stock beets do well. Potatoes are inclined to be a little soggy, unless thorough underdrainage is practiced. Apples, plums, and sugar beets do well. Shallow fall plowing is generally practiced. The type sells for \$45 to \$65 an acre.

The Fargo clay has a perfectly flat surface and the drainage is poor. The best crop yields are made in dry years. A large part of the type is used for hay land. Good corn, wheat, and oats are grown

when the season is not too wet. Little rotation is practiced outside of an occasional seeding to grass, pasturing or a change from grain to corn on account of moisture conditions. It ranges in price from \$40 to \$50 an acre.

The Marshall fine sand, because of its high organic matter content, is unusually productive for a sand. It yields from 25 to 45 bushels of corn, from 8 to 18 bushels of wheat, and medium to good crops of barley, rye, oats, grass, and flax. The heavier the rainfall the better the crop. It is ideally adapted to potatoes and vegetables. Cantaloupes, watermelons, and cucumbers undoubtedly could be grown with profit. The Marshall fine sand offers special inducements to intensive and diversified farming. It is inclined to suffer from droughts, and damage sometimes is done after fall plowing by blowing. Frequent applications of manure greatly improve the soil.

The Marshall fine sandy loam occurs as undulating prairie land and as rolling land in the neighborhood of streams. It maintains a very favorable supply of moisture and is used for general farming, producing very good yields. This soil is well adapted to potatoes, vegetables, and in the neighborhood of streams to fruit, particularly strawberries, raspberries, and blackberries. Clover does well and greatly benefits the soil when plowed under.

The Marshall loam is a well-drained, easily tilled soil adapted to general farming. Potatoes, cabbage, beets, alfalfa, etc., do well. The yields are about the same as on the Marshall silt loam. This is a very desirable but not an extensive type.

The Fargo fine sandy loam is a poorly drained soil. The subsoil is inclined to flow out and fill up the bottom of ditches, thus making the problem of drainage a difficult one. With the present very poor drainage the best use of the type is for hay and pasture land.

The Wabash silt loam occurs as first bottom or overflow land along stream courses. It is flat but generally well drained. High yields of corn, oats, and wheat are secured year after year from the same fields without apparent soil deterioration. Cultivation is easy and damage from overflow infrequent. This is a very desirable soil.

The Wabash fine sandy loam occupies the first bottom along streams. It is an excellent corn and oat soil. Good yields can be secured with continuous cropping without applications of manures. Onions and potatoes do well. Sugar beets of good quality can be grown, but the yields are apt to be light. Serious damage from overflow seldom occurs.

The Mankato sand occurs as a second terrace soil in the stream valleys. It has high organic matter content and produces good yields of corn, oats, and wheat. It could be utilized for market gardening. It is not an extensive type.

The Mankato sandy loam is a local type of limited extent and low agricultural value. It occurs as second terraces in the Minnesota Valley, and it affords good pasturage in moderately wet years.

The Judson loam occupies the slopes of valleys and the foot of bluffs. It is a very productive soil, some of the best wheat and oat yields in the county being secured from it. Much of it is too sloping for cultivation. The soil is especially adapted to apples and small fruits.

The Mankato loam is a local type of small extent occurring as second terraces in the Minnesota River Valley. Good yields of grain and corn are secured in moderately wet years. It is inclined to suffer from drought.

Peat represents accumulations of vegetable matter occurring for the most part in beds of old lakes. Where there is not much water some very heavy yields of slough grass are secured. In a few instances crops of corn have been grown on it. With better drainage a large percentage would make excellent wild hay land.

Meadow represents a condition rather than any definite type characteristic. It occurs in poorly drained depressions and along streams. Its most profitable use under present drainage conditions is for pasture and hay land.

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